Current Surgical Management II

A Book of Alternative Viewpoints on Controversial Surgical Problems

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Preface

This second volume of *Current Surgical Management* was undertaken because of the cordial and comforting acceptance of the first volume. It is not a second edition, or a revision, but rather an extension.

Through the kindness of friends, reviewers and gratuitous commenters who made suggestions, the editors and publishers were encouraged to consider further controversial topics or to present other facets of topics considered in Volume I. For this reason the Preface of Volume I, in which the objectives and aims are expressed, applies to this book. Also, in some subjects —treatment of duodenal ulcer, for instance—the controversy is carried along farther. Full appreciation of such discussions in this volume, therefore, will be gained only in the context of what was presented in the original first volume articles.

No attempt is made to cover the field of surgical activity. Few concepts in surgery are established so firmly that no controversy exists. A small item of new fundamental information, however, is capable of rocking what seem at the moment to be solid foundations. The more insecure these foundations are, the more likely will be differences of opinion. In selecting areas of discussion, the editors tried to avoid trivial matters and include those which arise commonly.

Again, contributors entered into the spirit of the effort with enthusiastic understanding. We are greatly indebted to them and to the publishers for deeply appreciated help.

JOHN H. MULHOLLAND

Preface to the Original Volume

Early textbooks on surgery were authoritative and final because the views and experiences of one individual were recorded. This was possible when the content of surgical knowledge was limited and one surgeon could meet with the whole subject in his activities. Wider knowledge and scope have made such a simple orderly course impractical. New information fragments the literature into segments and at the same time reduces the absolute authority of individual authors. The most searching investigator in a narrow field is likely to be the most uncertain of his ground. The more he learns the more he appreciates what there is still to be learned.

It is a curious paradox that writings on surgery in the period of relative ignorance could be dogmatic, whereas in the present period of great knowledge controversy is accepted. It was possible at the beginning of this century to lay down rules of conduct to meet most situations, so that the practicing surgeon had only to do what the book said should be done. Need for thinking about individual problems was reduced to a minimum. Countless discoveries and accomplishments have brought with them more speculation and more responsibility for thinking rather than less. The mechanical surgeon who might read rules and apply them by formula is farther away than ever before. A surgeon must remain a student and, to paraphrase a statement by Flexner, "employ his senses, aided and unaided, to elicit data that when put together enable him to construct a picture, the outstanding feature of which he tentatively labels. To visualize and solve problems, no two of which are ever alike—that is the concern alike of the practicing surgeons as of the University investigator."

Surgery is an inexact science. If all were known about

surgical diseases, there would be little need for surgeons. Search for the truth about obscure diseases will inevitably bring controversy and difference of opinion. When a conviction is arrived at by study and evaluation of experience, it is presented in the literature isolated and on the basis of factual data. There is overpowering and unjustified authority in a viewpoint so stated without rebuttal. This book is an attempt to present, side by side. varying viewpoints on certain surgical topics about which there is controversy.

In some instances. concepts are at variance because of fundamental differences, in others because of less basic disagreements such as the choice of, or timing of, an operation. The subjects chosen seemed to the editors to have legitimate divergence. While the book does not comprehensively cover all surgical problems, the topics selected should add up to those questions which commonly beset a surgeon.

It is impressive to find that what appears on the surface to be marked difference of opinion is not so marked when the ideas are more deeply probed. There are difficulties in communication which create conflict. For instance, even though an entity has a name which would be well understood by all, the controversialists may not be talking about the same thing. The bare term "peritonitis" may mean different things to different people; "radical operation" may mean only what the user intended it to mean. Also, comparison of statistical analyses of results of treatment may not be valid because samples used are not comparable. For example, patients screened from amongst many seeking treatment and who, because of complexity of disease, economic status. or some other factor. are sent to a special clinic or center cannot be collectively compared with the whole group.

A book such as this does not provide answers. It does demonstrate how certain authorities arrived at their own answers. Thus, a reader might be guided in that difficult and unavoidable decision which he must make for each patient he treats. Many factors in the decision cannot be written in a book and are concerned with the sick individual. The training and experience of the surgeon, facilities such as those for anesthesia. ancillary help and many other matters must be weighed in choosing a course.

The notion for the creation of this volume arose out of the

inclination of surgeons to argue their differences. The very successful "panel discussions" conducted by the American College of Surgeons are valuable to participants and audience alike because of controversies. All recognize that things are not settled, that knowledge is imperfect, and that there may be different ways to achieve an objective.

Contributors to the volume entered into the spirit and purposes with a zeal that made the editors' task wonderfully instructive. Many contributors seemed to welcome an opportunity to take up a specific argument in writing. It appeared that discussions face to face were more productive of understanding and that factual detached papers in the formal literature were unsatisfactory from the controversy standpoint. The aroused tone of some of the contributors, which makes for exciting reading, came about because the author was not knocking a straw man down, but actually coming to grips. The editors are grateful to all the contributors, not only for the writings, but also for decisive understanding of the purposes of the book.

The editors endeavored in introductions to sections to relate forethoughts regarding the controversies. An attempt has been made in these preambles to avoid arbitration or the taking of sides—sometimes a difficult commission.

The order of presentation of subjects is unusual. In the conventional book on surgery, it is customary to use regional anatomy as the basis for arrangement of chapters. Here, because the emphasis is on problems in general surgery the material is organized in some approximation of the magnitude of the problem in a general surgeon's experience.

In such a cooperative venture, acknowledgments and thanks must be widespread. Of special moment in this respect is our gratefulness to the W. B. Saunders Company for the original idea and for continued interest and help. The contributors in many instances also gave advice and suggestions which are acknowledged gratefully.

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Contents

Duodenal Ulcer and Its Complications 1

Roentgen Irradiation of the Stomach as an Adjunct to the Medical Treatment of Peptic Ulcer 5

Charles B. Clayman, Walter L. Palmer, and Joseph B. Kirsner

Vagotomy, Pyloroplasty, and Supra-antral Segmental Resection for Treatment of Duodenal Ulcer 9

Clarence J. Berne and William P. Mikkelsen

Bilateral Vagotomy and Antrectomy with Schoemaker-Billroth I End-to-End Gastroduodenostomy 15

J. Lynwood Herrington, Jr., and H. William Scott, Jr.

Segmental Resection for Peptic Ulcer 25

Owen H. Wangensteen

Polyps of the Colon 35

Treatment of Polyps of the Colon as Benign Lesions ... 37

John S. Spratt, Jr., and Lauren V. Ackerman

Radical Colectomy in the Treatment of Polyps of the Colon 42

Charles B. Ripstein

Relation of Polyps to Carcinoma of the Colon and Rectum 45

Bentley P. Colcock

REPAIR OF ESOPHAGEAL HIATAL HERNIA 55

Repair of Esophageal Hiatal Hernia by Fixation to the Abdominal Wall 57

R. Nissen

Transthoracic Repair of Hiatal Hernia 70

Donald B. Effler

The Abdominal Repair of Esophageal Hiatal Hernia 74

James H. Growdon

THE CHOICE OF OPERATION FOR CARCINOMA OF THE HEAD OF THE PANCREAS 83

Treatment of Pancreatoduodenal Carcinoma by Radical Duodenopancreatectomy 85

Jonathan E. Rhoads

Palliative Procedures for Carcinoma of the Head of the Pancreas 92

Roger D. Williams

DETECTION OF COMMON DUCT STONES 99

Operative Cholangiography 101

Joel W. Baker, John H. Walker, and G. Hugh Lawrence

The Detection of Stones in the Common Bile Duct. Operative Exploration 110

Deward O. Ferris

MANAGEMENT OF THE COMMON DUCT WOUND . . 119

Management of the Common Duct Wound by T-Tube Drainage 121

Henry Doubilet

Primary Closure of the Common Bile Duct 126
Leonard W. Edwards and J. Lynwood Herrington, Jr.

THE REPAIR OF COMMON BILE DUCT STRICTURE 135

Repair of Common Duct Strictures by Choledochojejunostomy 137
John H. Mulholland

End-to-End Repair of Bile Duct Strictures 140
Richard B. Cattell and John W. Braasch

MANAGEMENT OF THE NORMAL GALLBLADDER AT SPHINCTEROTOMY 145

Gallbladder Function Following Sphincterotomy 147
Robert E. Lempke

Removal of the Normal Gallbladder at the Time of Sphincterotomy 154
Alfred M. Large

THE PATHOGENESIS AND MANAGEMENT OF PILONIDAL SINUS 157

A Re-evaluation of the Pathogenesis and Appropriate Therapy of Pilonidal Sinus 159
Richard A. Raffman and Virginia Kneeland Frantz

The Selective Treatment of Pilonidal Sinus 169
Frank F. Allbritten, Jr.

CARCINOMA OF THE BREAST 173

The Choice of Treatment for Breast Carcinoma 175
C. D. Haagensen

GASTRIC SUCTION AND EARLY OPERATION VERSUS INTESTINAL DECOMPRESSION AND DELAYED SURGERY IN SMALL BOWEL OBSTRUCTION 185

Gastric Suction and Early Operation for Small Bowel Obstruction 187
Edwin H. Ellison

Use of the Long Intestinal Decompression Tube in the Management of Small Bowel Obstruction 197
M. O. Cantor

MANAGEMENT OF ARTERIAL INSUFFICIENCY OF THE LOWER EXTREMITIES 209

The Conservative Management of Arterial Insufficiency of the Lower Extremities 211
Louis G. Herrmann

Evaluation of Blood Vessel Replacement 224
Ralph A. Deterling, Jr.

Thrombo-endarterectomy for Occlusive Vascular Disease 238
Wiley F. Barker

Treatment of Arterial Insufficiency of the Lower Extremities by Lumbar Sympathectomy 243
Geza de Takats

THROMBO-EMBOLISM 253

Inferior Vena Caval Ligation for Thrombo-embolism . . . 255
Don R. Miller

The Use of Anticoagulants in Thrombo-embolism 262
John A. Schilling

ACUTE RENAL FAILURE 267

Diet and Fluid Regulation in Acute Renal Failure 269
Ernest S. Breed

The Use of the Artificial Kidney in Acute Renal Failure . 279

Henry H. Balch

Peritoneal Dialysis and Intestinal Perfusion in Acute Renal Failure 287

Paul R. Schloerb

PREOPERATIVE PREPARATION OF THE COLON 295

Preparation of the Bowel for Intestinal Surgery Without Resort to Antibiotics 297

Leland S. McKittrick

The Use of Antibacterial Agents for Preoperative Preparation of the Colon 301

Edgar J. Poth

PROLAPSE OF THE RECTUM 311

The One-Stage Perineal Operation for Prolapse of the Rectum 313

W. A. Altemeier, Laurence Greene, Jr., and Alfred Keirle

An Evaluation of the Orr Suspension Operation for Rectal Prolapse 322

George A. Higgins

INDEX OF CONTRIBUTORS 331

INDEX OF SUBJECTS 333

Duodenal Ulcer and Its Complications

Introduction

There are almost continual controversies concerning the treatment of duodenal ulcer and its complications. Ulceration of the duodenum could almost always be treated medically with satisfactory results were it not for its tendency to become complicated or refractory. Perhaps, if the etiology of this condition were better understood, treatment would be more universally the same for most patients. Little more is known regarding its pathogenesis than that there is acid-peptic digestion of a mucosa-susceptible area. The treatment, whether it is medical, psychiatric or surgical, centers on the suppression or control of acid hypersecretion. Two of the three phases of acid secretion by the gastric mucosa have been attacked most vigorously—the cephalic, psychic, or vagal phase, and the gastric, antral, or hormonal phase. The intestinal phase of acid secretion is not understood and there is even an indirect suggestion that there is a pancreatic phase.

In the first volume of *Current Surgical Management* the two direct surgical approaches to the first two phases of acid secretion were presented: vagotomy with pyloroplasty or gastroenterostomy versus subtotal gastrectomy. At the present time the scope of the controversy has broadened and problems of motor physiology have entered the ring where secretory function is still being tossed about.

One of the popular surgical treatments for duodenal ulcer at the present time attempts to ablate both the cephalic and the gastric phases of acid secretion by vagotomy and antrectomy. Physiologically, this has much merit for the above-

mentioned reasons, as well as the preservation of a larger than usual gastric reservoir. This increased capacity, over subtotal gastrectomy, is said to be important in the maintenance of body weight. Some of this advantage is nullified by the circumstance that gastric emptying is altered by the excision of the pylorus, which then may lead to postgastrectomy symptoms of "dumping."

Other re-popularized operations practiced at this time invoke an appreciation of an entirely new concept of acid regulation by the gastric antrum. This concept stems from the demonstration experimentally that the antrum probably elaborates a substance other than the usual histamine-like hormone, gastrin. The new "substance," sometimes called acid-inhibiting factor, was suggested when it was shown that if the antrum was stimulated by acid, for instance, there was an effectual reduction of acid secretion from the acid-secreting part of the stomach, a Heidenhain pouch Confirmatory studies led to the proposition that if the antrum were left in continuity with acid-secreting cells of the fundus, then the antrum could continue to regulate acid secretion. One could then merely reduce the amount of acid secretion by sleeve resection, wedge or segmental resection. Neither of the phases of acid secretion is removed, but acid reduction is accomplished and a reasonable gastric reservoir is maintained. If pyloroplasty is added, some of the advantages probably are lost again because of increased gastric emptying. If the pylorus is left intact and functional, much can be said to defend this procedure of sleeve gastrectomy. A duodenoplasty or transposition of the pylorus to the second portion of duodenum may be necessary for management of the specific ulcer changes.

Another method of management, that of X-irradiation of the stomach, has as much to defend it or promote it. As in the last-mentioned surgical approach, its object is to reduce acid secretion by the irradiation of the parietal gastric cells. Apparently it leaves the patient with a normal gastric reservoir with normal emptying properties, avoids operative treatment, and carries little or no risk. Its use might be more applicable to the patient with duodenal ulcer without the complications of hemorrhage or obstruction which are the usual indications for operation; however, in patients who become refractory to other forms of medical management it might be the management of choice.

It takes time, and the unprejudiced and objective evaluation of long-term results, to resolve controversial issues such as these concerning duodenal ulcer management. It is heartening, in spite of the broadened base of this controversy, to note that more and more physicians and surgeons are acquainting themselves with both the secretory and the motor functional changes invoked by their treatment. They are applying sounder physiological concepts in their management and giving up merely empirical forms of treatment.

S. R. F.

Roentgen Irradiation of the Stomach as an Adjunct to the Medical Treatment of Peptic Ulcer*

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Irradiation of the body and fundus of the stomach has been employed as an adjunct to the medical therapy of peptic ulcer since 1937. Bruegel established the feasibility of such an approach in 1917.[1] The rationale for the use of radiation stems from the desire to inhibit secretion of hydrochloric acid and from the difficulty encountered in control of the interdigestive phase of hypersecretion. While the strict program of milk and cream with antacid powders each half hour accomplishes neutralization of the acid in many patients during the day, the nocturnal hypersecretion is a problem, even under the most rigid regimens. With relaxation or modification of the schedule occurring so often in ambulatory patients, neutralization of the acid becomes increasingly imperfect.

The anticholinergic drugs developed to suppress acid secretion have fulfilled initial hopes only partially. None in therapeutically tolerable dosages will consistently induce achlorhydria or even profoundly reduce the overnight secretion. Thus, another avenue of acid control, that is, direct influence on the parietal cell by gamma ray energy, remains worthy of consideration.

Methods

The present technique of irradiation, as carried out in the Department of Radiology under the direction of Dr. James

* This work has been supported in part by a contract with the Atomic Energy Commission and by the Leo Wallach Fund for Research in Gastroenterology.

W. J. Carpender, is as follows:[2] After the ingestion of 250 cc. of regular chocolate-flavored barium-water mixture, the outline of the stomach is marked on the skin under fluoroscopic control. The orthodiascopic method is used to insure accuracy. The patient breathes normally during the procedure. Marking is done in both prone and supine positions, with the arms at the sides. Depending on the size and shape of the stomach, 13 by 13 cm. or 10 by 17 cm. portals now are outlined over the gastric fundus. Small marks are tattooed in each corner using India ink. On the following day, after the barium has left the stomach, treatment is started. Both portals are treated daily thereafter for ten treatment days. The depth dose is estimated in a plane lying one-third of the distance from the anterior surface of the body and two-thirds the distance from the posterior surface of the body. Although the stomach may vary somewhat from this position, the change in depth dose from a point one-fourth of the anteroposterior diameter to three-fourths of the anteroposterior diameter is not more than 10 per cent. Using 250 kv., 25 ma., 50 cm. focus skin distance, 1 mm. Cu and 1 mm. Al filter (half-value layer 1.5 mm. Cu), a skin dose is selected so that the combined daily contribution to the fundus from both portals provides a tissue dose of 160 r minimum. Thus, in ten treatment days the gastric fundus receives a minimum tissue dose of 1,600 r. The course of therapy is repeated only in selected cases and usually only after an interval of several years.

A moderate number of patients experience anorexia or nausea during therapy. There is usually a mild erythema of the skin in the portal areas; in the more obese patients, this reaction may be intense. No serious injury to the skin has been seen, even when the course has been repeated once or twice.

Evaluation of response to therapy has been made in the following ways: (1) Clinical appraisal of the patients' symptoms. (2) Standard two-hour gastric analysis with midpoint Histalog stimulation before, immediately after, and three weeks after completion of therapy. Tests are repeated every three to six months until the secretory pattern returns to pretreatment levels or until five years have elapsed. (3) Roentgenologic examination of the crater at monthly or bimonthly intervals until it is healed.

Results

Duodenal Ulcer

Medical therapy including roentgen irradiation has resulted in an overall recurrence rate in five years or more of about 35 per cent. This figure was obtained in a group of 1,024 men and women seen between 1937 and 1950 and followed to 1958 or death. This compares with five-year recurrence rates of 75 per cent reported in the literature. Using a different method of appraisal, it may be said that the annual incidence of recurrence of ulcers has been reduced from a pre-therapy rate of 1 per patient year of observation to about 0.2, while the rate for hemorrhage decreased from 0.04 to 0.01 per patient year.[3] Sixteen per cent of the group ultimately required surgery.

Over the entire 20-year follow-up period (with a greater than 98 per cent follow-up) only 1 per cent of the patients died from ulcer or its complications. On the basis of a study nearly completed, it is believed that the number of deaths (42) from malignant neoplasm was in no way influenced by the irradiation.

Gastric Ulcer

While hyperchlorhydria is not the rule, one requisite for chronic gastric ulcer is hydrochloric acid, which activates pepsinogen to pepsin. The conclusion follows that continued achlorhydria permits the ulcer to heal and remain healed. In a group of 116 such patients, favorable results have been achieved in 62 per cent followed five years. Seven per cent of the group were classed as failure to heal; 24 per cent were failures due to recurrence. Of the entire group, 26 per cent ultimately came to surgery.[4]

Miscellaneous

A few patients with peptic esophagitis secondary to hiatal hernia, a few with marginal ulcers, and a few elderly patients whose short life expectancy and overall status rendered them dangerous risks for surgery have been irradiated with good results.

Summary

Radiation therapy must be considered an adjunct and not an alternate to medical therapy. In our experience, it has been of sufficient value to incorporate it into the general program of treatment. A reduction in gastric acidity has been accomplished in most patients for varying periods of time. Transient achlorhydria occurs less often. In no instance has an ulcer failed to heal when the achlorhydria has lasted three months or longer.

Conclusion

Radiation therapy is a safe and useful adjunct to the medical management of peptic ulcer.

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Vagotomy, Pyloroplasty, and Supra-antral Segmental Resection for Treatment of Duodenal Ulcer

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An ideal operation for cure of duodenal ulcer should adequately suppress the ulcerogenic mechanism without creating undesirable physiological disturbances. Subtotal distal gastrectomy with Billroth II type of reconstruction is generally accepted as the standard procedure for the treatment of chronic duodenal ulcer. In its present advanced state of development the principal technical features of the procedure are uniform; the operative risks, the degree of ulcer control, and the resultant physiological disturbances are known.

Further progress in the surgical control of duodenal ulcer will necessarily come from efforts concentrated on the development of a more physiological procedure. The magnitude of the standard gastrectomy has been determined by trial and error, beginning with pylorectomy and gradually being increased to the present standard three-quarter resection. Because any complete gastrojejunal shunt eliminates duodenal ulcer, three-quarter gastric resection is not adjusted to the control of duodenal ulcer disease. Rather, as it has evolved, it represents the magnitude of gastrectomy necessary to prevent jejunal ulcer in most patients so treated. The foregoing situation has caused many surgeons to be engrossed with other than the basic problem, which is to delineate the requirements for control of duodenal ulcer.

Importance of the Duodenum

On the basis of existing evidence, gastroduodenal continuity is a desirable feature of ulcer-curative surgery. Acid chyme in the duodenum furnishes the stimulus to the duodenal mucosa for production of the pancreas-stimulating hormone, secretin. Secretin activates the production of acid-neutralizing pancreatic juice. Also, secretin probably inhibits gastric secretion produced by the antral hormone. Enterogastrone provides a similar inhibiting action. These duodenal hormonal mechanisms are not maximally stimulated after gastrectomy because of the resultant hypochlorhydria. However, they could be useful in maintaining control over gastric acid produced during digestion, if such were compatible with elimination of duodenal ulcer disease.

The buffering of acid chyme by duodenal secretions from Brunner's glands and the fluids draining from the papilla of Vater is maximal in the proximal duodenum. There is very strong evidence that the duodenal mucosa above the papilla is inherently much more resistant to acid injury than is that of the jejunum.

Role of the Antrum

Intimately involved with duodenal physiology are the functions of the antrum. The antrum is preserved when duodenal ulcer is treated by vagotomy and pyloroplasty; by pyloroplasty and sleeve resection; by antral exclusion, vagotomy, and gastrojejunostomy; and by the procedure that we are to describe. There is no clear evidence that the antrum contributes importantly to the dominance of the secretory components of the ulcerogenic mechanism in duodenal ulcer disease. Its hypermotility is eliminated by truncal vagotomy or the mural vagotomy incident to sleeve resection. Functionally the antrum constitutes a cylindrical segment between the acid pepsin-producing ulcerogenic segment and the anti-ulcerogenic duodenal segment. Although the antrum is inactive during fasting, while distended by food it produces the parietal cell stimulating hormone, gastrin. When physiologically adequate concentrations of acid reach the antrum, the production of gastrin decreases. This passively reduces acid secretion. Further, there is evidence

that the cut-off mechanism involves active antral inhibition of acid secretion. The antrum, placed between the two opposing mechanisms, is therefore probably biphasic in its behavior, initially assisting and later suppressing acid production.

Basic Concepts of Ulcer Curative Surgery

There is general agreement that the basis for successful ulcer-curative surgery is adequate reduction of the secretion of gastric acid, especially during fasting. Usually this reduction can be accomplished by complete elimination of the cephalic phase by vagotomy. Also it can be accomplished by an adequate end organ resection of the parietal cell area.

Another basic consideration in duodenal ulcer surgery involves the surgeon's concept regarding excision of the ulcer. The basic premise of medical treatment of duodenal ulcer is that the ulcer will heal if the ulcerogenic motor and secretory factors are adequately controlled. We are unaware of failure of pyloroplasty and vagotomy to control duodenal ulcer where the vagotomy has been complete, except when done for giant ulcer. Such evidence leads us to conclude that excision of the ulcer is seldom necessary. Omission of ulcer excision, inherent in preservation of the antrum, eliminates technical risks of real importance. Injury to the common bile duct and pancreatic ducts and problems incident to duodenal stump closure are eliminated.

An unexplained feature of duodenal ulcer is that the lesion is usually a punched-out defect and not a diffuse ulceration. If the acid pepsin factor were solely responsible for duodenal ulcer, a diffuse ulceration would be expected. One explanation, for which there is experimental evidence, is that localized ulceration is determined by the jet effect of acid chyme leaving the pylorus. This is produced by a combination of pylorospasm and pyloric canal hypermotility. Both are characteristic of duodenal ulcer. Parasympathetic denervation of the antrum by truncal vagotomy or gastric transection minimizes the motor factor. Pyloroplasty eliminates narrowing at the pylorus.

Loss of pyloric valve function is inherent in every known procedure directed at cure of duodenal ulcer. Consequently, some degree of dumping syndrome will occur after any such procedure. Its intensity, related to many factors, will be impor-

tantly conditioned by the degree of preservation of gastric reservoir function. Reservoir size is maximally preserved when Heineke-Mikulicz pyloroplasty plus vagotomy is done for duodenal ulcer.

Vagotomy and Pyloroplasty

Clear, definite, uncontrovertible proof exists that vagal overstimulation, especially during hours when the stomach is empty, is the major etiologic factor in duodenal ulcer. It is difficult to understand the reasoning by which the conclusion is reached that any form of curative surgery for duodenal ulcer should not include vagotomy. The only evidence controverting such a generalization is seen when only vagotomy is done. This has been described as a pure experiment. Because of the resultant poor gastric emptying, such a procedure is actually an experiment in antral hypertension and therefore antral hyperfunction. This does not occur if an adequate antral drainage procedure is also performed. Pyloroplasty provides this decompression. We have had a large experience with pyloroplasty and vagotomy as well as with gastrectomy for duodenal ulcer and believe that the former has given at least as good ulcer control as the latter.

It is our opinion that gastrojejunostomy should seldom be used with vagotomy. The regurgitation of jejunal content into the stomach is an acid-stimulating mechanism. Also, this regurgitation may produce gastritis. Further, gastrojejunostomy complementary to vagotomy may be followed by the same complications that occur following gastrojejunostomy with gastrectomy. Pyloroplasty became a functionally satisfactory procedure after the development of the "one-row" technique. If, in the performance of this pyloroplasty the duodenum is extensively mobilized, it moves ventrally and to the left. Experience has taught us that this mobilization is the other important element of a well functioning pyloroplasty.

Segmental Resection Through Gastric Corpus

Resection of a segment of the parietal cell area will quantitatively reduce acid secretory response to the stimuli persisting after elimination of the cephalic phase by vagotomy. This

reduction can be quantitated by the size of the resection. There is evidence that a 50 per cent resection of the corpus will, without any adjuvant procedure other than pyloroplasty, often control duodenal ulcer. Such a resection leaves a good-sized gastric reservoir and largely avoids the small stomach syndrome.

Additive Effects of Vagotomy, Pyloroplasty, and Supra-antral Segmental Resection

Synthesis of all the foregoing considerations into a technically feasible operative procedure is accomplished by pyloroplasty, vagotomy, and supra-antral segmental resection of the gastric corpus (Fig. 1). Physiologic crippling is minimal in consonance with the more normal anatomical end result. The procedure avoids the technical problems of distal gastric resection and reconstruction inherent in any type of gastrectomy. The sleeve resection is done through normal tissue which can be brought to the surface for this step of the operation. Each phase of the procedure is correlated with laboratory and clinical experience. It represents the coordination of a large amount of experimental evidence as compared with empiricism in the development of the standard type gastrectomy. It is presented as a probationary surgical procedure, primarily because of the

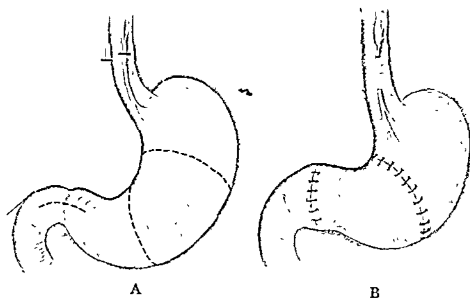


Fig. 1. Vagotomy, pyloroplasty, and supra-antral segmental resection for treatment of duodenal ulcer. *A*, The incisions. *B*, After suture.

theory that it incorporates. We have used it with satisfaction, in selected cases, since 1951.

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Bilateral Vagotomy and Antrectomy with Schoemaker-Billroth I End-to-End Gastroduodenostomy

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Background

The fact that several basic operative procedures with numerous detailed modifications have been described for the treatment of duodenal ulcer is convincing evidence that surgeons have not been entirely satisfied with the overall results of operative therapy for this disease. An "adequate" subtotal gastric resection is at present the most widely used operative procedure for duodenal ulcer. Generally, the results with this surgical approach have been good, but recurrent ulceration continues to appear in 2 to 5 per cent of patients despite the fact that 70 to 75 per cent of the stomach has been removed. Also to be considered are the distressing postgastrectomy sequelae that are encountered in a sizable percentage of the patients who are followed over the years. It was the result of a combination of these factors that influenced us several years ago to abandon this radical operative approach in the treatment of this benign disease. During the past twelve years, the great majority of patients with duodenal ulcer on our service who required surgical treatment have been subjected to a bilateral subdiaphragmatic vagotomy combined with resection of the gastric antrum. A Billroth II type of anastomosis was employed almost exclusively during the earlier years, but in recent years an increasing number of patients have undergone a Billroth I type reconstruction along with vagotomy and antrectomy.

A Physiologic Surgical Approach

In our opinion, complete vagotomy coupled with excision of the gastric antrum appears to be a sound physiologic surgical approach to the duodenal ulcer problem.[1, 4, 5, 6, 9] Both the cephalic and humoral phases of gastric secretion are eliminated by the combined procedure, yet sufficient gastric tissue remains so that the stomach continues to function as a storage organ. Postoperative gastric secretory studies have repeatedly shown that there is an absence of free hydrochloric acid during the fasting state and no free hydrochloric acid response to stimulation with a test meal. Over 90 per cent of the patients thus treated have an achlorhydria following stimulation with histamine. The postoperative quantitative secretory volumes of gastric juice are lowered to within the normal range or below the range found in normal individuals. Under such circumstances it would appear that recurrent ulceration would be unlikely, indeed.

It is our preference at present, after carrying out vagotomy and antrectomy, to re-establish gastrointestinal continuity with an end-to-end gastroduodenostomy. The utilization of the duodenum for the reception of the gastric contents has been shown to result in less loss of fecal fat and nitrogen as compared to the Billroth II type of reconstruction. Reports by other authors mention fewer dumping symptoms, better nutritional states, and less likelihood of postoperative anemias when gastroduodenal continuity is preserved.

Operative Technique

It has been our custom to employ a modification of the incision described by Kehr[8] or the one cited by Cole[2] in order to gain exposure of the upper abdominal contents The superior aspect of the incision should extend to the costal margin on the left of the ensiform cartilage in order to provide adequate exposure of the abdominal attic The suspensory ligament of the left hepatic lobe is always divided and the lobe retracted to the right. A detailed report of the technique employed in performing a complete vagotomy has been reported elsewhere and will not be repeated.[3] Suffice it to say, however, that adequate time and care should be given to a thorough search of the peri-

esophageal area for the presence of any accessory nerve fibers after division of the main trunks.

Following vagotomy and reperitonealization of the esophageal area, attention is next directed toward removal of the gastric antrum and ulcer-bearing duodenum. The antral tissue is known to comprise a greater length on the lesser than on the greater curvature. An arbitrary point is selected on the lesser curvature proximal to the approximate midpoint between the pyloric vein and the esophagogastric junction. This point is usually 2 to 4 cm. proximal to the incisura angularis. A similar *midway point is selected on the greater curvature. Two straight* Kocher clamps are next applied to the greater curvature at the previously selected midway point. These grasp a segment of gastric wall approximately the same width as the duodenum and in such a manner that the clamps are at a 90 degree angle to the long axis of the stomach. It is important, as will be discussed later, that the clamps be placed at this angle rather than at an angle of less than 90 degrees in reference to the longitudinal axis of the stomach.

The gastric tissue is now divided between the Kocher clamps. From this point of division, two straight clamps are then applied in an oblique fashion to the lesser curvature to just above the point previously selected on the lesser curvature for division (Fig. 1). The application of the latter clamps at an oblique angle allows for tubing of the gastric pouch as originally described by Schoemaker The stomach is next completely transected between the latter two clamps. The lesser curvature portion of the proximal gastric pouch is then closed with running sutures of 00 chromic catgut in two layers reinforced with an outer inverting layer of interrupted 0000 silk. The Kocher clamp placed on the greater curvature portion of the pouch is left in position to be later used in the performance of the end-to-end gastroduodenostomy.

The transected distal stomach, consisting of the antral segment and occupying approximately 40 to 45 per cent of the total gastric surface area, is now reflected to the right. The duodenum is kocherized and the bulb dissected free from the underlying areolar tissue and pancreatic capsule. Caution is taken not to injure the common bile duct or pancreatic ducts when dealing with an adherent posterior wall ulcer. The transected distal stomach is used as a lever by the operator, and

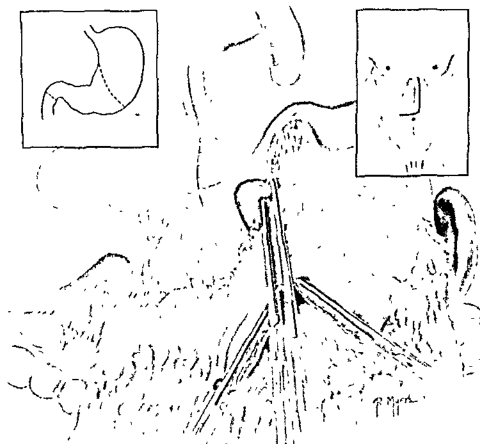


Fig. 1. The greater curvature of the stomach has been divided between Kocher clamps Clamps have been placed to the lesser curvature to complete the division of the stomach.

traction gently applied to this structure facilitates greatly the dissection of an adherent duodenal bulb. The duodenum is usually mobilized distal to the ulcer for a distance of 1 to 2 cm. A point on the posterior duodenal wall below the site of ulceration is then selected for the site of gastroduodenal anastomosis

The cut end of the proximal gastric pouch along the greater curvature, which is still occluded by the previously applied Kocher clamp, is next rotated and prepared for anastomosis to the duodenum. A posterior layer of interrupted 0000 silk sutures is placed between the greater curvature aspect of the gastric pouch and the posterior wall of the duodenum below the site of ulceration. The sutures extend into the submucosal layer. Usually seven to ten sutures are needed, depending on the width of the opposing gastric and duodenal walls. The sutures are each carefully placed and the knots are not tied at this point (Fig. 2). After the last suture has been taken, the first

assistant gently displaces the gastric pouch to the right by utilizing the Kocher clamp applied to this portion of the stomach. At the same time, he places his left index finger lateral to the duodenum and gently displaces the kocherized duodenum forward and to the left. This maneuver brings the two structures to be anastomosed into perfect apposition. The posterior layer of previously placed silk sutures is then held taut by the second assistant and each suture is carefully tied by the operator (Fig. 3). These sutures serve to bring the serosa of the gastric pouch and the corresponding duodenal serosa into close apposition. The specimen, consisting of the distal 40 to 45 per cent of the stomach and the ulcer-bearing duodenal bulb, may be excised at this point, or else removed just prior to tying the posterior row of interrupted silk sutures.

The Kocher clamp is removed from the gastric pouch and

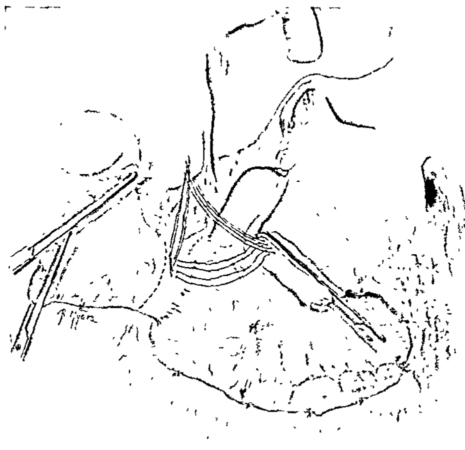


Fig 2 The lesser curvature aspect of the gastric pouch has been closed The greater curvature portion of the stomach is being anastomosed to the duodenum below the ulcer site The posterior seromuscular layer of fine silk sutures is being placed.



Fig. 3. The stomach pouch and duodenum are brought into close apposition. The posterior layer of interrupted silk sutures are being tied.

the crushed tissue is excised. A posterior row of 000 or 0000 continuous chromic catgut sutures is next placed, which includes all layers of the opposing gastric and duodenal wall, care being taken to include only small bites of tissue. The previously placed row of interrupted sutures are held taut while the continuous catgut suture is placed, as this maneuver allows for better visualization and ease in performing this part of the anastomosis. As the catgut suture advances, each corresponding silk suture is divided. The continuous catgut suture is next brought anteriorly as an inverting stitch and the ends are tied as they meet anteriorly in the midline (Fig. 4). An outer layer of interrupted 0000 silk sutures completes the anastomosis (Fig. 5). Again, it should be emphasized that only very small bites of tissue are included and at the completion of the anastomosis the gastroduodenal stoma will usually admit 1 to 2 fingertips. The stoma is estimated not to exceed 1.5 to 2.5 cm. in size.

The very small amount of difficulty with emptying of the

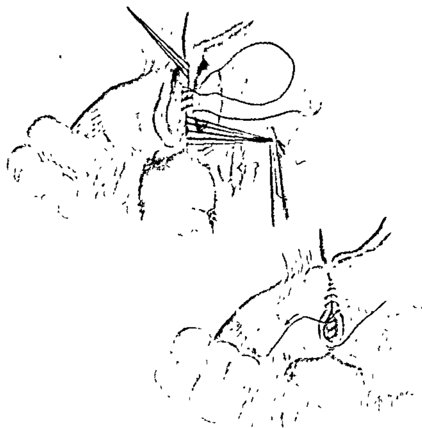


Fig. 4. The fine continuous suture of chromic catgut is being placed posteriorly. This suture is then continued anteriorly as an inverting stitch.

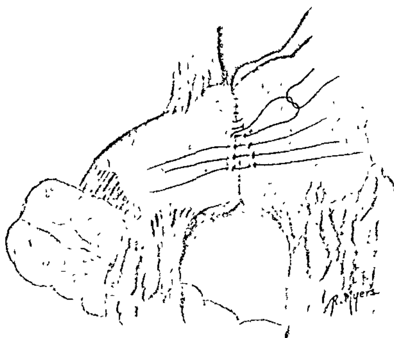


Fig. 5. The interrupted fine silk sutures are being placed anteriorly to complete the anastomosis.

stomach after this type of anastomosis in our experience may well be attributed to the utilization of very fine suture material and the inclusion of only small bites of tissue in performing the anastomosis. Also, we think it is important in preparing the greater curvature of the stomach for anastomosis to the duodenum that the gastric wall be transected at a 90 degree angle in reference to the greater curvature. If any stenosis is encountered in the descending duodenum, division of the antimesenteric border of this structure for a distance of 1 to 1.5 cm. will overcome the problem.

Clinical Experience

During the past four years, approximately 300 patients with the usual complications of duodenal ulcer that require surgery have been subjected to bilateral vagotomy and antrectomy with gastrointestinal continuity established by end-to-end gastroduodenostomy. This method of reconstruction was used only sparingly during our early experience, being particularly applicable at first to the duodenal ulcer which was not intimately adherent to the pancreas and not surrounded by dense scar tissue. With increasing experience the Schoemaker-Billroth I reconstruction has been used with greater frequency, including the more difficult penetrating ulcers of the posterior duodenal wall. Of course, there are certain circumstances, notably those in which a postbulbar ulcer exists, in which the Billroth II reconstruction is more feasible. We have not used the Schoemaker-Billroth I technique unless the ulcer could be excised. However, it is estimated at the present time that approximately 85 per cent of the patients with duodenal ulcer who are submitted to definitive surgery on our service receive a Billroth I type of reconstruction after vagotomy and antrectomy.

Postoperative complications following vagotomy, antrectomy and gastroduodenostomy have been small, indeed. Emptying difficulties have not been a major concern and have been encountered in only a few instances. Errors in judgment during our early experience with the Billroth I reconstruction were responsible for most of the stomal problems, as certain patients operated on at the time should no doubt have been repaired by the Billroth II method. As experience with the

technique has increased, postoperative gastroduodenal obstruction has been practically eliminated. As previously mentioned, the utilization of fine suture material and the incorporation of small bites of tissue in performing the anastomosis are factors responsible for the good results. It has been our objective to create a small gastro-enteric stoma because we are convinced that a small gastric outlet is less conducive to postprandial difficulties.

Follow-up studies show that less than 10 per cent of the patients with vagotomy, antrectomy and gastroduodenostomy have lost weight since operation and weight loss has rarely been excessive, usually ranging from 10 to 20 pounds. Anemia has not been a problem. Symptoms suggestive of the dumping syndrome have been present in approximately 25 per cent of these patients, as compared to 40 per cent of those treated by vagotomy and antrectomy with a Billroth II type of reconstruction. In the former group, the symptoms have been mild and transitory in nature. It is of interest that not a single instance of severe dumping syndrome has been encountered in patients with a Billroth I reconstruction. However, in a similar group with a Billroth II reconstruction, symptoms of dumping have been severe enough in several patients to warrant conversion to a Billroth I anastomosis.

A follow-up period extending to four years has not been of sufficient length to permit long-range evaluation of the incidence of recurrent ulceration. However, up to the present time, there has been only one case of recurrent ulcer in the group of 300 patients treated by vagotomy and antrectomy with a Billroth I reconstruction. It is suspected, but not yet definitely substantiated, that this single patient with recurrence had an incomplete vagotomy. Ninety-five per cent of the group of 300 patients have obtained a very satisfactory result over this follow-up period.

It is our opinion at present that vagotomy and antrectomy with a Billroth I reconstruction has definite and decided advantages over the Billroth II method. The gastroduodenal method of reconstruction is now being used on most of the patients in our institution who are subjected to surgery for duodenal ulcer. The method has a definite advantage from a nutritional point of view in the patient who is below weight prior to operation. It is also the method of choice in all female patients when tech-

nical considerations permit. The Billroth II reconstruction, however, may at times be the wisest and safest choice, particularly when dealing with certain distal and densely adherent posterior wall ulcerations which cannot be adequately and safely removed.

Summary

The operation of bilateral vagotomy and antrectomy with end-to-end gastroduodenostomy appears to be a physiologic surgical approach to the duodenal ulcer problem.

The operative technique has been described.

The incidence of weight loss, anemias and dumping syndrome has been less in our experience after vagotomy and antrectomy when the Billroth I rather than the Billroth II reconstruction was used.

Our preference is to perform a Schoemaker-Billroth I gastroduodenal anastomosis, along with vagotomy and antrectomy, whenever technical considerations permit.

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Segmental Resection for Peptic Ulcer

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Historical Perspective

Segmental resection is not a new operation for peptic ulcer. It was used for a period of about a decade, more than fifty years ago, by German surgeons for gastric ulcers on the lesser curvature, above the infundibulum.[5] The operation was devised, named, and abandoned by Mikulicz in 1897. A few years later, Riedel (1909, 1912) and Payr (1909, 1910) took up with the procedure again but it had a short-lived history. It was observed that patients having this operation encountered difficulty in gastric emptying, and occasionally hour-glass constriction was observed at the line of suture.

In taking up with segmental gastric resection in 1949, primarily for duodenal ulcer, somewhat more than fifty years after Mikulicz's description and abandonment of the operation, I had to learn independently that transverse division of the stomach is accompanied by gastric retention and delay in emptying. I resolved this problem by adding a complemental pylorotomy, concluding that transverse division of the stomach interrupted the vagal innervation to the antrum and pylorus.[5]

My surgical colleague, Dr. Donald J. Ferguson[1] (1953), in performing segmental resection, elevates the structures along the lesser curvature of the stomach, thus preserving the vagal twigs to the pylorus and antrum. Moreover, in doing this, Ferguson finds it unnecessary to do a complemental pyloroplasty save in the presence of organic obstruction, or in approximately 20 per cent of patients undergoing the operation for duodenal ulcer.

Rationale of Segmental Resection

Surgeons generally appear to entertain prejudice against retaining the antrum when gastric resection techniques are employed in the surgical management of peptic ulcer. However, it is to be pointed out that there is an important difference between *antral exclusion* and *retention* of the antrum in physiological continuity. It was on this thesis that I posited my belief in the promise of segmental resection[5] (Fig. 1).

Resection techniques of dealing with peptic ulcer stem from employment of the same procedures for gastric cancer. Distal gastrectomy for pyloric and antral cancers preceded proximal gastrectomy for fundic cancer by many years. It is not extraordinary, therefore, that surgeons in their search for a satisfactory technique of dealing with duodenal ulcer should have come gradually to elevate the line of excision from below, upward.

The first gastric resections done for pyloroduodenal ulcer were essentially small pylorectomies. Surgeons were soon to learn, however, that even complete excision of the antrum, based on the Edkins' factor of hormonal (gastrin) stimulation, was to prove an inadequate operation for duodenal ulcer. By 1934, Finsterer had come to the conclusion that a two-thirds distal resection was necessary in order to protect against recurrence when operating for duodenal ulcer on the Billroth II plan.

Criteria of an Acceptable Operation for Peptic Ulcer

The ideal operation for peptic ulcer has not been found. In surgery, as in life, it is often necessary to be satisfied with something less than perfection The assurances which we would like to provide patients to whom an operation for relief of peptic ulcer is proposed are: (1) protection against recurrent ulcer; (2) minimal operative risk; (3) absence of undesirable side effects. No operation meets all these tests with a perfect score, but segmental resection satisfies these criteria probably as well as any operation yet devised.

Indications for Segmental Resection

Segmental resection is adaptable to any peptic ulcer, save the antral ulcer. For these, a distal gastrectomy must be done.

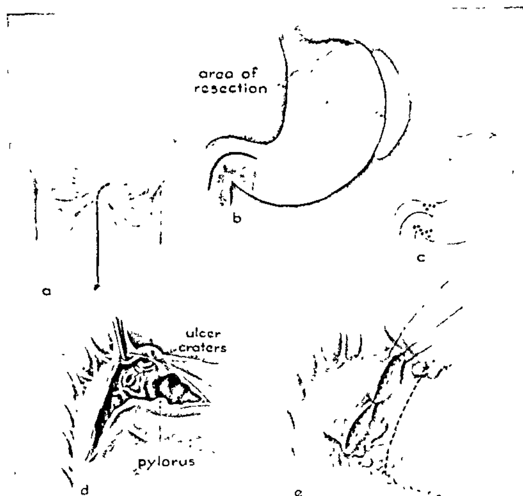


Fig. 1. Segmental resection as done initially in this Clinic (1949 to 1952). *a,* Incision *b,* The extent of excision, leaving only 10 to 15 per cent of the entire acid-peptic secreting area. *c,* The maximal concentration of parietal and chief cells is in the light area; a lesser concentration in the upper fundic region, and only a few scattered cells occasionally are encountered in the antrum *d,* The Heineke-Mikulicz pylorotomy made initially. Now employed only in the presence of very narrow strictures of the duodenum. *e,* The closure of the pylorotomy opening For contrast, observe the simplicity of closing a transverse pylorotomy incision as shown in Figure 3 (*a* to *f*).

The Billroth I procedure, unprotected by a truncal vagotomy, appears in the light of recorded experience (Haberer 1939; Ordahl 1955; Goligher 1956; and Wallensteen 1957) to be an inadequate operation for duodenal ulcer.[6] The reason for this defection would appear to be occasioned by the resultant low pH values at the neostoma when the acid peptic juice from the fundus is poured directly into the short duodenal segment, proximal to the ampulla, no longer protected by the intervention of the antrum.[4]

Technique of Segmental Resection

An operative diagnosis of the character of the lesion present is the first responsibility of the surgeon when operating for peptic ulcer. In massive gastric hemorrhage, when operation is undertaken, the adaptability of segmental resection becomes apparent. A transverse pylorotomy, as shown in Figure 3, *a*, *b*, permits inspection of the duodenum. If a bleeding point is present, it is encircled with a fine chromic catgut stitch. When a crater is present, the adjacent edges of the duodenal mucosa are coaptated by a few interrupted chromic catgut sutures, thus excluding the crater as shown in Figure 2, *b-e*. If no lesion is found in the duodenum in operations undertaken for massive gastric hemorrhage, transverse division of the stomach above the antrum affords an opportunity to inspect the antral and the fundic segments.

Bleeding from a gastric erosion or occult gastric ulcer calls for only a small excision. Hemorrhagic gastritis demands wide excision of the acid-peptic secreting area. Today an emergency operation for massive gastric hemorrhage is not as compelling as it was prior to adoption of local gastric cooling in the control of such bleeding.[7] The closure of the pyloroduodenal opening is accomplished as shown in Figure 3, *c-f*.

The surgeon now demarcates what he believes to be the true gastric antrum, preserving the vessels along its greater and lesser curvatures. The resection is a combination of the closed and an open anastomosis. A residual fundic pouch, constituting approximately 25 per cent of the stomach, or a segment of that size allowed to remain in the conventional three-quarter distal gastrectomy, is preserved.

The section on the lesser curvature is carried up to include

the left gastric artery. It is important to leave approximately 4 to 6 cm. of lesser curvature, thus avoiding any encroachment upon the esophagogastric juncture.

Reconstitution of gastric continuity is effected as shown in Figure 3, *g-k*. A running seromuscular chromic catgut stitch approximates the two segments. The two clamps are then removed. Both gastric pouches are well evacuated by suction. A running catgut stitch penetrating the full thickness of both segments effects a satisfactory mucosal apposition; at this juncture, the inlying gastric tube lying in the upper end of the fundic pouch is advanced with a ring forceps into the duodenum (Fig. 3). A series of interrupted 5–0 silk sutures suffices to effect a satisfactory peritoneal inversion.

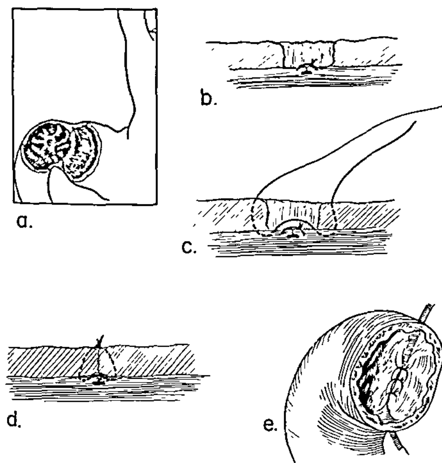


Fig. 2. Technique of dealing with the duodenal ulcer crater in segmental resection. *a,* An opportunity to inspect the duodenum and lower antrum is readily afforded through the pylorotomy opening. *b,* Stitching the bleeding point in the crater with chromic catgut. *c, d,* Placement of interrupted sutures of chromic catgut to exclude the ulcer crater. *e,* Completion of the suture.

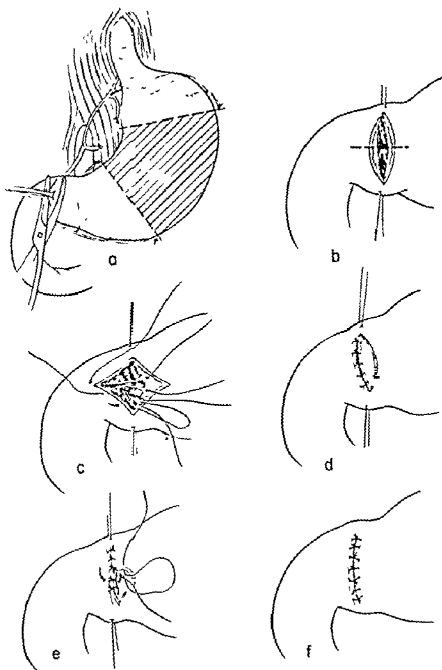


Fig 3. (For legend, see opposite page.)

Results

Segmental resection is probably the most conservative of all resection techniques. It preserves normal anatomic continuity. In my early segmental resections (1949–1952) referred to herein as extensive segmental resection, I left only a 10 to 15 per cent fundic pouch.[6] There were 97 resections in this group and no recurrences have been observed in the eight to eleven year interval.

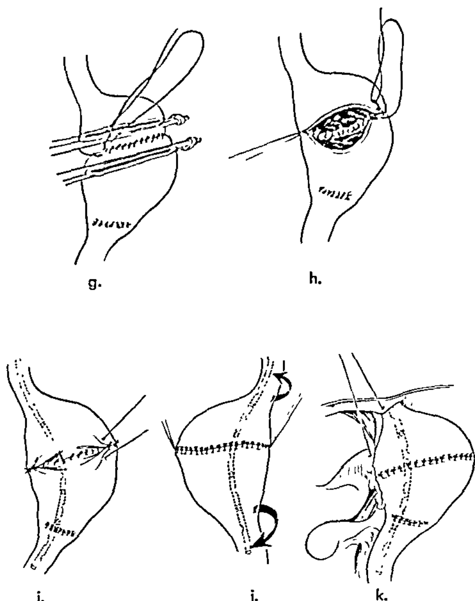


Fig. 3. Technique of segmental resection. *a*, Extent of resection. *b*, Manner of making pyloroplasty *c*, *d*, Closure of defect with a few interrupted sutures of chromic catgut, approximating antral mucosa to full thickness of duodenal wall. *e*, *f*, Placement of external row of interrupted sutures of 5–0 silk to complete closure. In *e* and *f* the muscle layer on the gastric side slides over the mucosal closure. *g*, *h*, *i*, *j*, *k*, Technique of effecting the anastomosis. *g*, The closed anastomosis clamps have been applied and a posterior seromuscular running suture of chromic catgut is placed. *h*, Posterior running suture of chromic catgut approximating all layers from within; beginning of the anterior running catgut suture. *i*, Placement of interrupted sutures of 5–0 silk anteriorly. *j*, Rotation of the gastric segments to place similar sutures posteriorly. *k*, Completed anastomosis with indwelling tube extending on into the duodenum.

Ferguson[2] and his associates at the Veterans Hospital in Minneapolis have had a large experience with segmental resection. In a survey of 185 patients with duodenal ulcer followed for one to five years after segmental resection, Ferguson has observed three recurrences, an incidence of 2.2 per cent. During the same period, a control series of Billroth II resections (three-quarter resection) was done. The recurrence rate was 4.6 per cent. Ferguson still continues to do the large segmental resection which I performed initially between the years 1949 and 1952, but adds a pyloroplasty only when obstruction is present (20 per cent of cases). Failure to free the antrum from its vagal innervation and the absence of the pyloroplasty may be in part responsible for the observed recurrences in these extended segmental resections of Ferguson.

Because of the frequency with which the dumping syndrome followed extensive segmental resection (about the same incidence as attended the three-quarter Billroth II resection), I began looking about for another operation which would thwart the ulcer diathesis but would prove a bit more acceptable to the patient. I then had an interlude of almost three years with tubular resection and transverse gastroplasty, an operation which I was forced to admit fails to protect against recurrent ulcer. I then returned to segmental resection and began doing a small resection, excising from 25 to 33 per cent of the stomach; 91 small segmental resections were performed between 1955 and 1957; two recurrences have been observed, suggesting the need for a somewhat larger excision. In one patient, a granuloma was present about a through-and-through 4–0 silk suture in the posterior suture line of the original gastrogastrostomy, an occurrence which prompted discontinuance of use of silk, save for the external serous stitch. During the past four years, a 50 per cent segmental resection has been performed almost exclusively for duodenal ulcer. In operations for benign gastric ulcer, above the antrum, a lesser resection suffices. Sixty-nine patients have undergone hemigastrectomy on the segmental plan. No recurrences have been observed during this short interval. To segmental hemigastrectomy, with antral denervation and pyloroplasty, a complemental truncal vagotomy has been added in a few patients, too recently operated upon to permit valid adjudication.

Conclusion

A 50 per cent segmental gastric resection, as described herein, appears to meet, as well as any available operation, the desiderata of an adequate operation for all peptic ulcers (save the antral ulcer). It can be performed with a low mortality (less than 2 per cent) and is accompanied by a low incidence of recurrence; and the patients as a group, in our experience, are freer from undesirable side effects than with other resection procedures.

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Polyps of the Colon

Introduction

One of the most difficult decisions confronting a surgeon is that dealing with the management of a polyp of the colon beyond reach of a sigmoidoscope. The price of certainty is the risk of a formidable operation. To consider all such lesions innocent will result in some costly blunders; to treat all as malignant lesions will result in unnecessary morbidity and mortality. We are dependent on empirically established guides.

The three following discussions are based on experience.

J. H. M.

Treatment of Polyps of the Colon as Benign Lesions

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Polyps Within Reach of the Sigmoidoscope

Cancers of the colon and adenomatous polyps of the colon cannot be differentiated one from the other except by histological examination. Consequently, whenever a tumor is found within a part of the large bowel that can be seen through a sigmoidoscope, removal of a part or all of the tumor for biopsy is to be performed. This statement could not be made so dogmatically should the mortality rate attending the transendoscopic removal of small tumors from the rectum and sigmoid colon exceed the likelihood of a given rectal or sigmoidal polypoid tumor being a cancer. For, should the mortality rate attending the removal of adenomatous polyps exceed the likelihood of a polypoid tumor's being a cancer, then one would merely be substituting an iatrogenic death for a neoplastic one.[7] The maximum likelihood of a polypoid tumor's being a cancer is determined by the data in Table 1 giving the proportion of cancers to polyps in a standard population of one million.[5]

Consequently, histological examination of the biopsy specimen governs what should be done further with any polypoid tumor of the colon within the range of the sigmoidoscope. If the tumor is a retention (juvenile) polyp, usually nothing further need be done because these tumors never become cancer. Adenomatous polyps containing focal atypia and carcinoma-in-situ are cured simply by removal of the polyp. Similarly, adenomatous polyps containing focal cancer in their tips without any evidence of invasion of the stalk are cured by local excision because these "focal cancers" do not metastasize.[5, 6] Vil-

TABLE 1. AGE ADJUSTED INCIDENCES OF CANCERS AND POLYPS OF THE COLON AND RECTUM IN A STANDARD POPULATION OF ONE MILLION

Age Groups	*Frequency Distribution of Cancers of the Colon in a Standard Population of 1 Million*	*Frequency Distribution of Polyps of the Colon in a Standard Population of 1 Million*	*Ratio of Cancers to Polyps*
20–29	5	1,300	1:260
30–39	16	10,000	1:625
40–49	50	9,000	1:180
50–59	98	15,000	1:150
60–69	124	15,000	1:120
70–79	120	8,500	1:80
80+	40	1,500	1:40
TOTALS	453	60,300	1:130

lous (papillary) adenomas so frequently have invasive cancers within them that they should be treated by an operative procedure designed for the cure of infiltrating metastasizing cancer of the colon.[5]

Polyps Beyond Range of the Sigmoidoscope

The real problem is what to do with polypoid tumors discovered roentgenographically, and located beyond the range of the sigmoidoscope. Hultborn has concluded that it is impossible to differentiate the small benign from the small malignant tumor of the colon radiographically.[4]

For a time we believed that the existence of melena pointed to a malignant tumor. However, we have found that blood in the feces is associated with benign polyps with such frequency that its detection is really of no value in differentiating benign from malignant colonic tumors.[6]

The one characteristic of colonic tumors that is correlative with their histologic nature is the tumor's size. Figure 1 is a graph of the frequency of benignity and malignancy of colonic tumors relative to the greatest cross-sectional diameter of the tumor (excluding the length of pedicles). The data for Figure 1 were obtained from the measurements of 128 benign colonic tumors and 228 malignant colonic tumors removed from consecutive, predominantly symptomatic persons.[6] Among 91 tumors up to 1.2 cm. in diameter, only one cancer was found, while among 265 tumors larger than 1.2 cm. there were 227 cancers. Significantly, the chance that a colonic tumor 1.2 cm. or

greater in diameter will be a cancer produces a risk of death that unquestionably exceeds that attending its removal either by colotomy and polypectomy or by open segmental colectomy.[2, 6] Since the radiographic shadow of an intracolonic tumor is larger than the tumor is after its removal and fixation, the indubitable discovery of a shadow of a polypoid tumor measuring 1.2 cm. or larger constitutes an adequate basis for recommending its removal.

In order not to produce an iatrogenic death rate that is higher than the neoplastic death rate, the transabdominal removal of colonic tumors with a diameter of 1.2 cm. or less must be effected with a mortality rate of less than 1 per cent. We have observed one operative death following the removal of such small tumors from 16 persons by colotomy and polypectomy and no deaths from their removal from 10 persons by open segmental colectomy (1 of 26, 3.8 per cent). However,

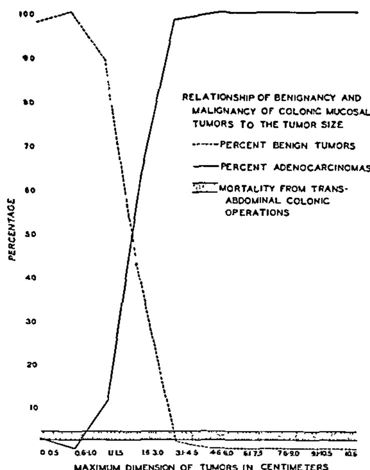


Fig 1. The percentage of cancers and polyps in each size range as classified by the greatest cross-sectional diameter of the tumor.

TABLE 2. TIME REQUIRED FOR A DE NOVO CANCER TO ATTAIN A DIAMETER OF 1.5 CENTIMETERS

Cancer Diameter at First Observation	*Number of Doubling Times Required to Attain 1.5 cm. Diameter*	*Days Required to Attain 1.5 Diameter*	
		Minimum (49 days d t)	*Maximum* (123 days d t.)
De Novo Cancer	31.7	1553	3899
0 2 cm.	9 7	475	1193
0 5 cm.	4 8	235	590
0 7 cm.	3 8	186	367
1 0 cm.	1 8	88	221
1 2 cm	1 0	49	123

only nine persons died following the transabdominal resection of malignant colonic tumors from 268 persons, and all nine were 65 years of age or older. Whenever conditions known to significantly increase the operative mortality rate are present, polypoid tumors of the colon 1.2 cm. or less in diameter above the range of the sigmoidoscope might better be watched than removed.

Whenever one elects to observe rather than remove a small tumor from the colon, one must observe the tumor for an increase in size, the size increase being the earliest index of the presence of cancer in the tumor. From the data in Table 2, calculated from the doubling time of rectal cancers metastatic to the lung,[1] one may see that repetition of the barium enema examination at three to six-month intervals will be sufficiently frequent to detect size increases in small polypoid tumors of the colon 1.2 cm. in diameter or less having doubling times between 49 and 123 days.

Conclusion

Since cancers and adenomatous polyps of the colon are indistinguishable except by histological examination, all rectal and lower sigmoidal polypoid tumors seen through a sigmoidoscope should be removed in whole or in part for histological examination. Retention (juvenile) polyps usually require no further treatment. Adenomatous polyps with focal atypia, carcinoma-in-situ, and focal cancer without stalk invasion are curable by local excision. Villous (papillary) adenomas so fre-

quently contain invasive cancer that they must be resected as cancers.

The only characteristic or symptom of small polypoid tumors beyond the range of the sigmoidoscope that correlates with the presence of cancer is size. The chance of a tumor larger than 1.2 cm. in diameter being a cancer exceeds the mortality rate from removing it by either colotomy with polypectomy or open segmental colectomy. Removal of tumors 1.2 cm. in diameter or smaller must be done with a mortality rate of less than 1 per cent in order not to substitute a higher iatrogenic death rate for the expected neoplastic death rate. Based on the doubling time concept, data have been presented to show that small colonic polypoid tumors beyond the range of the sigmoidoscope may be observed for increases in size, the earliest index of cancer in them, by repetition of the barium enema examination at three to six-month intervals.

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Radical Colectomy in the Treatment of Polyps of the Colon

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The frequent association of malignancy with polyps of the colon has led to the concept that the benign polyp is a premalignant lesion. In this respect the sessile adenoma has been considered more dangerous than the pedunculated polyp largely because invasion of the bowel wall occurs earlier. Various estimates have been offered as to the percentage chance of malignancy developing in a polyp. In polyps more than 1 cm. in diameter the approximate risk of malignancy is 5 per cent. Since each polyp must be considered to carry a similar risk, it is obvious that the more polyps present in a colon, the greater the chance of developing malignancy. The ultimate risk is in familial polyposis where hundreds of lesions are present and the incidence of malignancy is 100 per cent.

We have been impressed by the fact that a large number of patients who have had polyps of the colon excised locally in adult life have returned years later with more polyps or a carcinoma of the colon. Furthermore, it is well known that patients surviving a resection for carcinoma of the colon run a greater risk of a second primary lesion in the bowel than the general population of the same age group. In our material, 27 (6 per cent) of 450 patients undergoing colon resection ultimately developed a second primary lesion. When those patients who died within five years were excluded, the figure rose to 15 per cent. In a group of 60 adult patients who had local excision of polyps, five developed a carcinoma of the colon within a five-year period.

Such a risk might be acceptable if the diagnosis of recur-

rent lesions were exact. In our experience, however, a great many early tumors are missed even by careful barium and air contrast studies. Though a small lesion may be discovered, metastases may have already occurred.

Clinical Experience

In order to test the validity of our concept, subtotal colectomy to the level of the rectosigmoid was performed in two groups of patients. Group I (100 cases) consisted of all patients with a single carcinoma of the colon whether or not polyps were discovered on palpation or colotomy. Group II (30 cases) consisted of adult patients with three or more scattered polyps above the level of the rectosigmoid.

The chief purposes were to determine the actual incidence of polyps of the colon and the frequency of malignant change, and to assess the more radical operation in terms of mortality and postoperative morbidity.

In Group I, 40 patients had multiple (more than three) polyps of the colon associated with carcinoma and in eight cases malignant change was present either as a frank carcinoma or malignant change in a polyp. Three malignant tumors were palpated in the colon; the remaining five were unsuspected until the specimen was opened and examined by the pathologist. From this experience it would appear that many of the so-called second primaries of the colon are present at the time of resection of the first lesion and are unrecognized until months or years later when they produce clinical symptoms or grow large enough to be recognized on barium enema. The surgical mortality in this group was 9 per cent and this was about the same as that in a similar group treated by standard localized excision. This mortality is higher than that encountered in private practice but is equivalent to that observed in city hospitals. In any case, no increased mortality could be directly attributed to the more extensive resection. The only specific postoperative problem related to the extent of resection was frequency of bowel movement. This occurred in most patients but was temporary in all cases except where a long segment of terminal ileum was removed.

In Group II there was no surgical mortality and, since in every case the terminal ileum was left intact, no lasting

morbidity. All patients were found to have more polyps than were visualized by x-ray examination. As an example, in one case four polyps were seen on air contrast study, seven were discovered by palpation and colotomy, and 18 were found in the resected specimen. Even though small polyps are of little immediate significance they may increase in size as the years go by. In two cases an unsuspected carcinoma was found.

Tentative Conclusions

From this experience we are convinced that multiple polyps of the colon frequently accompany clinical carcinoma and that second primary lesions may be present in a fair percentage of cases. In younger individuals in whom the operation is thought to be curative, a more radical resection is indicated; the entire colon to the level of the rectosigmoid should be excised. Limited resection should be reserved for poor-risk patients, for palliative resections, and for those patients whose long-term prognosis is doubtful because of associated disease. The mortality and morbidity of the more extensive procedure has been acceptable. It is still too early to assess the results in terms of cure.

Polyps of the colon in adults are considered to be potential malignant lesions. The x-ray does not give a true picture of the number of polyps and may not demonstrate malignancy. When three or more polyps are scattered in different areas of the colon, radical colectomy must be considered.

It is unwise to draw final conclusions from a small series of cases and a short follow-up but it does seem that some of our ideas must be changed. A careful follow-up of all patients with carcinoma and polyps of the colon should be mandatory and autopsy examination must be carried out in all deaths from this disease. As the evidence accumulates, the truth will become clear.

Relation of Polyps to Carcinoma of the Colon and Rectum

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There is considerable evidence to indicate that adenomatous polyps of the colon and rectum are precancerous lesions. Most surgeons believe that the detection and removal of these lesions constitute an opportunity to prevent the development of cancer of the colon and rectum. If the polyp is already malignant, its detection permits the removal of a cancer of the colon or rectum at a stage when it is almost 100 per cent curable.

On the other hand, the potentially malignant nature of these adenomatous polyps has recently been questioned by Spratt, Ackerman and Moyer.[12] These authors feel they have evidence to support the view that "adenomatous polyps possess little or no propensity for malignant degeneration." They cite Colvert and Brown,[4] Rider et al.,[11] and Kirsner et al.[6] as also believing that adenomatous polyps are not precancerous growths. This very important point has a direct bearing on our treatment of any patient with a polyp in the colon or rectum and also any patient with a carcinoma of the colon or rectum. Regardless of how he feels about this question, the abdominal surgeon cannot disregard these lesions, because at the present time an early polypoid carcinoma can be definitely distinguished from a benign mucosal polyp only by microscopic examination. For this reason, if for no other, the lesion which we call an adenomatous polyp plays a vital role in the diagnosis and treatment of cancer of the colon and rectum.

Distribution

Most observers have noted an increase in the occurrence of both polyps and carcinoma with increasing age. In the experi-

ence of Spratt et al. the frequency of occurrence of adenomatous polyps in persons over 50 years of age, with and without carcinoma of the colon, was identical. They considered this finding as evidence that polyps are not precancerous.

With few exceptions, surgeons have found a striking similarity in the distribution of adenomatous polyps and carcinoma throughout the colon and rectum. In a series of 901 patients operated on at the Lahey Clinic for cancer of the colon and rectum throughout a five-year period, 77.8 per cent of the lesions occurred in the rectosigmoid and rectum.[13] Other recent reports show an almost identical distribution of cancer throughout the colon and rectum.[10] In our experience, over 50 per cent of benign polyps occur in this same area. Spratt et al., on the other hand, found that the frequency of cancer per unit length of intestine was higher than the frequency of polyps in the cecum, sigmoid, and rectum, while the reverse was true in the remainder of the colon. They also noted that in the right colon the polyps associated with carcinoma were found distal to this lesion in 17 of 18 times, and in the sigmoid and rectum, the polyps were located proximal to the associated carcinoma in 45 of 51 times. They thought these findings discredited the belief that adenomatous colonic polyps are prone to become malignant. The exact significance of these observations is at least debatable.

The air contrast enema study, upon which we must depend for detection of polyps in the proximal colon, is less accurate than proctoscopic examination of the distal colon and rectum. Therefore, the true incidence of polyps in the proximal colon may be higher than we have found. Indeed, it is because of this and because they feel so strongly the importance of detecting and removing adenomatous polyps that Lillehei and Wangensteen[7] have advocated subtotal or total colectomy for any patient requiring colectomy for a lesion distal to the hepatic flexure. For the same reason, many surgeons carry out endoscopic examination of at least the left colon when operating for carcinoma of the colon and rectum.[1,3] This procedure is particularly important if the presence of a second lesion—benign or malignant—has not already been ruled out by adequate roentgenologic examination, including air contrast enema study.

Perhaps a clue to the answer to this question lies in the observation that small polyps have been found to disappear.

Even an experienced roentgenologist may miss an adenomatous polyp of less than 5 mm. in diameter in the cecum or ascending colon, while all polyps that occur in the rectum and low sigmoid will be seen on proctoscopic examination. Small polyps may come and go in all parts of the colon, and only those that persist and increase in size are likely to be detected by radiologic examination. It is reasonable to assume that those polyps which are malignant or are going to become malignant will persist and increase in size. I believe that the frequency of this particular type of polyp is highest in the distal colon and rectum, and that its distribution is very similar to that of ulcerating carcinoma. Certainly, it is a matter of experience that malignant intestinal lesions are most likely to occur in the descending colon, sigmoid and rectum, and that often the malignant lesion is in the form of a polyp. A polyp of the rectum has been observed to increase slowly in size over a two-year period and finally, when biopsy was carried out, carcinoma was found. It is difficult to prove that such a lesion represents carcinoma arising in a previously benign polyp, but it is also very difficult to prove that this is not the case. As observed through the proctoscope, the appearance of such a lesion is that of a benign mucosal polyp.

Association of Polyps and Carcinoma

The frequency with which polyps have been found in the resected specimens of patients who have been operated on for ulcerating carcinoma of the colon or rectum has long been reported. In our experience, benign polyps have been found in the resected specimens in 25 per cent of the patients who have undergone resection of the colon and rectum for carcinoma. A second malignant tumor has been found in the colon or rectum in 4 per cent of our patients, and in most instances it was in the form of a polyp. In one case, three separate carcinomas were found in the resected specimen—a large, ulcerated growth and two polypoid carcinomas. The outward appearance of the malignant polyps was identical, except for size, with that of a benign polyp which was also present in the same specimen. Other observers have found that carcinoma occurs five times more frequently in patients with polyps than in patients without polyps. In a follow-up study of 300 patients who had had a benign

adenomatous polyp removed, other benign polyps were subsequently found in 12 and cancer developed in ten.[14] A startling reminder of the close association of these two lesions is shown in the report by Mayo and Schlick.[8] Of 131 patients who came to autopsy following operation for carcinoma of the colon and rectum, polyps were found in the remaining portion of colon in 49, or 37.4 per cent, and a second carcinoma was present in seven, or 5.3 per cent.

Lillehei and Wangensteen[7] found that occult polyps were present in 21 of 55 patients who had undergone subotal or total colectomy for polyps or carcinoma of the colon; they felt these lesions would have been missed had this more extensive type of colectomy not been performed. By means of this more extensive procedure they found three occult carcinomas in 43 patients operated on for cancer and in five patients a second carcinoma developed in six months to seventeen years following a previous partial colectomy. Thus, simultaneous or successive independent carcinomas of the colon developed in eight of 43 patients (18.6 per cent). This again indicates the vital importance of removing all polypoid lesions of the colon or rectum in patients being operated on for carcinoma of the colon or rectum. This holds true whether we consider all malignant polyps to be malignant from the beginning or to represent malignant degeneration in a previously benign lesion. Certainly, the close association of ulcerating carcinoma and benign and malignant polyps would seem to be more than mere coincidence.

Congenital Polyposis

The close association of congenital polyposis and carcinoma of the colon is well known. Unless death is caused by other factors or colectomy is carried out, carcinoma of the colon will probably develop in every patient with congenital polyposis. Dukes[5] has carefully studied 1069 members of 58 families. Polyps were found in 20 per cent and carcinoma in 14 per cent. Of those patients who had polyposis, carcinoma occurred in 70 per cent. The average age at onset of the typical symptoms of diarrhea and bleeding was 20 years, the average age at onset of carcinoma was 35 years and the average age at death from carcinoma was 41 years. Spratt et al. found that the locational frequencies for carcinoma of the colon in patients with familial

polyposis were the same as in patients having colonic cancer without polyps. They felt this was evidence against any association of the two lesions. However, it may simply mean that polyps in patients with or without familial polyposis are more likely to become malignant or to be malignant when they occur in the distal colon and rectum.

If one feels that there is no relationship between the high incidence of polyps and the high incidence of carcinoma in these patients with familial disease, the implication is that the malignant lesion arises from the colonic or rectal wall between the polyps. Since these polyps are so numerous that they cover the entire mucosal surface of the large intestine and rectum, this is a difficult point to prove. We have had two patients in whom malignant disease developed in the rectal stump following anastomosis of the ileum to the rectal segment. However, continuous follow-up observations were impossible in these two cases and a benign polyp or at least an early malignant polyp might well have preceded the ulcerated carcinoma which developed in the rectum of each patient. After regular follow-up examinations, with rigorous fulguration of any rectal polyps that appeared, carcinoma subsequently developed in only one of 27 patients treated at St. Mark's Hospital[9] (London). Many patients with familial polyposis have been treated successfully in a similar manner in this country.

Ulcerative Colitis

It is well recognized that carcinoma of the colon or rectum is more likely to develop in patients with long-standing chronic ulcerative colitis than in the average person. The occurrence of carcinoma in patients with severe ulcerative colitis of many years' duration is at least 10 per cent and has been reported to be as high as 25 per cent. The polypoid appearance of the intestinal mucosa, which may be seen in many of these patients, represents islands of mucosa separated by scar tissue, rather than multiple adenomatous polyps. This fact has been cited as evidence against the origin of carcinoma in polyps. However, true polyps do develop in patients with chronic ulcerative colitis, and at least some of the carcinomas which occur in patients with ulcerative colitis develop in these polyps. In one of the few five-year survivors among our patients with chronic

ulcerative colitis and carcinoma of the colon, the adenocarcinoma was found in a 4 cm. polyp in the rectosigmoid. The polyp was found on proctoscopic examination during a routine check-up examination for the ulcerative colitis, and it had the typical appearance of a pedunculated polyp such as those seen in patients who do not have ulcerative colitis.

Clinical and Microscopic Appearance

Some authors have stated that a short pedicle indicates more rapid development of the adenomatous component of a polyp and therefore such a lesion is more likely to be malignant. Induration in the pedicle of any polyp which can be palpated is suggestive of cancer; on the other hand, a long pedicle does not necessarily mean that the polyp is benign. Size alone is also not a dependable criterion in deciding whether these polypoid lesions are benign or malignant, although it is probably true that some small polyps disappear spontaneously. The small, soft, movable, nonulcerated polyp is usually benign, but polyps 1 cm. or less in size have been found to be carcinomatous. Every polypoid carcinoma at one stage in its development is small, and the diagnosis of carcinoma should not be delayed until ulceration occurs. We must conclude that there are no physical characteristics which will reliably identify a polyp as benign and likely to remain benign. Only microscopic examination will exclude the presence of carcinoma, and then only if the biopsy specimen includes all of the polyp and its base.

On histologic examination, all degrees of malignancy may be found in adenomatous polyps. The abnormal proliferation of the epithelium may be confined to the tip of the polyp, and some of these lesions could be classified as carcinoma in situ. It is quite reasonable, therefore, that such a lesion might show little tendency to spread, or might even disappear spontaneously Turnbull[15] has carried out follow-up studies in a number of patients in whom this type of polyp was locally excised; he found no evidence of subsequent metastases. Yet we know that carcinoma in situ of the cervix may be present for seven to eight years before becoming invasive. Had these polyps not been found and removed, a similar progression of malignant degeneration might in time have occurred. Indeed, Buie[2] has observed a patient who refused treatment for a pedunculated

polyp of the rectum; metastatic carcinoma developed from this lesion in a period of seven to eight years. A diagnosis of cancer should not be based upon the mere presence of numerous mitoses. Epithelial cells may occur within vessels or as artifacts produced by cutting the tissue. On the other hand, definite lymphatic or vascular invasion means clinical carcinoma. Our pathologists have emphasized that all portions of the biopsy specimen should be examined before a negative report is made; otherwise, a small focus of malignancy may be overlooked.

If a benign mucosal polyp has been completely removed and the base fulgurated, it does not recur. If such a polyp does recur, carcinoma should be suspected and further biopsy studies carried out. Our experience would indicate that removal of a polyp with a long, soft pedicle is adequate treatment even though early carcinoma is present in the tip of the polyp. Moreover, we base this decision on a frozen section diagnosis, at the time of the colotomy. If the lesion is a large sessile polyp with no pedicle, a segmental resection may have to be carried out so that the pathologist can examine all of the polyp. On the other hand, if invasive carcinoma is found in such a polyp, or if invasion of the pedicle of a pedunculated polyp is present, segmental resection is not sufficient and a radical cancer operation should be carried out. When such a lesion occurs in the rectum, in which case the alternative procedure would be an abdominoperineal resection with a permanent colostomy, I prefer to carry out an anterior resection with anastomosis of the descending colon to the lower rectum. I am more willing to do this at a lower level and with a smaller margin of normal bowel below the lesion (not less than 3 cm.) than I would be for a large, ulcerating carcinoma.

Summary

An adenomatous polyp of the colon or rectum is considered by most surgeons to be a premalignant lesion. This opinion is based on considerable clinical evidence indicating a close association of the two lesions. Direct proof of the transformation of a benign mucosal polyp to carcinoma is lacking, but neither can it be proved that this does not occur. Further study may settle this very important point. In the meantime, we also lack a dependable means of distinguishing a

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benign mucosal polyp from an early polypoid carcinoma except by biopsy. Because the carcinoma may be present in only a portion of the polyp, an adequate biopsy requires complete removal of the lesion.

Since these lesions are so frequently multiple (25 to 40 per cent of cases), if a benign polyp is found in the colon or rectum others must be searched for. The other polyp may be malignant. Because associated polyps are present in 25 per cent of patients with carcinoma of the colon or rectum, the remaining portion of the colon and rectum should be examined for these lesions. In at least 4 to 6 per cent of patients with cancer of the colon or rectum, two or more simultaneous or successive independent carcinomas of the colon or rectum will develop. Thus, the need for a prolonged follow-up is obvious.

In the light of our present knowledge, a polypoid growth arising from the mucosa of the colon or rectum represents one of three possibilities. First, it may be a benign but potentially malignant lesion and its removal may actually prevent the development of carcinoma. Second, it may be an early polypoid carcinoma in which the cure rate following resection should approach 95 per cent. Third, it may be a benign lesion, the removal of which involves no significant mortality and is the only certain way of eliminating the first two possibilities. If this is so, we must continue to look for and remove polyps of the colon and rectum.

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Repair of Esophageal Hiatal Hernia

Introduction

The management of herniation through the esophageal hiatus has been a controversial issue since the recognition of the condition by Morgagni in 1769. As a matter of fact, the clinical symptoms of hiatal hernia, until comparatively recently, were frequently confused with and attributed to associated diseases, including cholelithiasis, narrowing of the coronary arteries, acid peptic disease, unassociated lesions of the esophagus, and organic diseases of the lung. The reasons for this confusion are self-evident when one realizes the frequent coexistence of these disease entities in the elderly obese patient who presents her or himself with a hiatal hernia. In addition, the symptoms of an esophageal hiatial hernia, particularly if it is large or complicated by esophagitis or incarceration, simulate closely those commonly attributed to these more common ailments of mankind. Thus dysphagia, acid regurgitation, vomiting and hemorrhage are common with the secondary esophagitis. Pulmonary and cardiac symptoms, including cough, dyspnea, angina-like pain, and palpitation are frequently seen if the hernia is large or incarcerated. Furthermore, although the mechanism is not completely understood, peptic ulceration may occur as a result of and be located within the herniated portion of the stomach. The result and symptoms must not be attributed to a postulated but nonexistent ulceration of the duodenum or uninvolved stomach. Finally, it has become general knowledge that the herniation associated with an enlarged eophageal hiatus and its symptomatology is progressive without surgical intervention and that medical management in symptomatic hernia is without benefit.

The recognition of these important facts by our medical

Repair of Esophageal Hiatal Hernia by Fixation to the Abdominal Wall

R. Nissen

University Surgical Clinics, Basel, Switzerland

At the outset of an article designed to deal with a particular form of operative correction of hiatal hernia, it is as well to point out that by far the commonest type of hernia—the sliding hernia—is comparatively seldom the cause of discomfort sufficient to justify surgical intervention. In many cases, the hernia is in itself an insignificant phenomenon, albeit a particularly striking secondary finding during x-ray examination for other organic diseases of the stomach or the duodenum (e.g., ulcer, carcinoma, coronary vascular disease, chronic pancreatitis, cholecystitis).

Far simpler is the problem of operative indication in the case of para-esophageal hiatal hernia. Here, the danger of incarceration and strangulation is so great that surgical intervention is advisable in practically all cases.

Whereas the disorders in the para-esophageal type can easily be explained on the basis of strangulation of a greater or lesser degree, it seems improbable that such a process plays a part in the case of sliding hernia. At all events, we have frequently inflated the stomach through a Levin tube in the course of operative exploration, but have never detected anything comparable to a state of effective strangulation. Nor did incision of the tendinous ring of the hiatus have any effect on the manifestations. This method was first applied nearly thirty years ago, on the assumption that strangulation did in fact occur, at a time when the unfavorable results of narrowing the hiatus by surgical intervention began to become apparent. It would seem nearer the mark to ascribe the disorders associated with sliding hernia in some cases to restriction of the retro-

colleagues has resulted in renewed interest on the part of the surgeon in correcting this condition. The fundamental principles of repair embody, first, the reduction of the herniated stomach, and second, prevention of re-herniation either by repair of the diaphragmatic defect or by fixation of the stomach to the anterior abdominal wall. A transperitoneal or transpleural approach to the average hiatal hernia would seem at first glance to be largely a matter of personal preference; however, advocates of either method are quick to point out advantages or disadvantages of each. Those advocating an abdominal approach are concerned about the high incidence of associated abdominal disease and the necessity of correcting it to assure the most satisfactory result for the patient. Those supporting a transthoracic approach object to unplanned operative procedures in the abdomen and point out the feasibility of repair of all types of hiatal hernia, regardless of existing complications (i.e., esophagitis with stricture, or the finding of a short esophagus), when the transpleural approach is employed. A more adequate exposure, easier reduction of the herniated viscus in repair as a hiatal defect, improved morbidity and mortality rates in the elderly poor-risk patient, and a lower recurrence rate are claimed by advocates of either approach.

Reduction of the herniated stomach by gastropexy alone to prevent recurrence has been suggested as a more simplified approach to the problem. Although it was advocated initially as an emergency measure in elderly poor-risk subjects, the end results have been said to be sufficiently satisfactory to warrant its routine usage. An additional procedure, namely fundoplication, has been suggested as being of value to prevent reflux of gastric contents in those patients with associated esophagitis.

Arguments for and against each method of approach and/or repair of the esophageal hiatal hernia are well presented by the authors of this section. The final decision must be left to the reader. It should be pointed out, however, that this decision in the case of a particular patient may well depend not only on the technical skill or know-how of the surgeon but more often on his own evaluation of the risk involved and his knowledge of the diagnostic acumen of his medical associates.

E. H. E.

About the same time (1951), we began—tentatively at first—*using this procedure for sliding hernia of the esophageal hiatus also.* When after a three-year observation period, no signs of relapse, either anatomical or symptomatic, were apparent, gastropexy became for us the method of choice. Today, our experience with this method covers more than 220 cases.

Meanwhile, Boerema, unaware of our first publication (1954), had chosen the same method for the elimination of hiatal hernia (1955).

Our grounds for abandoning hernioplasty in favor of gastropexy for sliding hiatal hernia were as follows:

When, nearly thirty years ago, Akerlund and Berg first pointed to the high incidence of sliding hiatal hernia, the Sauerbruch Clinic, to which the author belonged at that time, had ample occasion to study the problem of treating this condition by surgical means. Operative narrowing of the dilated hiatus produced unsatisfactory results, irrespective of whether the abdominal or the thoracic approach was used. Since that time, we have tested every one of the operative methods proposed, including that of Allison, which, based on the principle of forming a new hiatus, seems to us to present the most solid form of reconstruction. Despite this, we observed anatomical relapse in 50 per cent of our cases, though admittedly recurrence of the preoperative symptoms was confined to about one-third of patients. Some of the relapses with which we had to deal followed on interventions originally performed elsewhere.

Allison's operation, solving the problem of hernioplasty well as it does, yet entails several drawbacks. To begin with, it represents a formidable intervention which one is understandably loath to apply in the case of elderly people who represent 45 per cent of our patients. Secondly, it destroys the physiological connection binding the cardia with the diaphragm. Lastly, the thoracic approach makes it almost impossible to exercise dependable control over the abdominal organs, let alone to perform additional interventions, such, for instance, as removal of the gallbladder in cholelithiasis or resection in case of gastric or duodenal ulcer.

By contrast, gastropexy leaves the connection between cardia and diaphragm intact and thoracic bulging of the parietal peritoneum is prevented by turning the latter inside out caudalward like a funnel.

cardial space, but in most cases in all probability to *reflux esophagitis.* The origin of this condition will be dealt with later. Certainly, it would seem to afford the most natural explanation of the tendency to hemorrhage exhibited by such patients.

Historical Perspective and Rationale of Gastropexy

As regards surgical correction of *para-esophageal hernia,* the only difference of opinion concerns the best method of approach. Sauerbruch, a firm protagonist of the transpleural method, argued that surgical usage demanded opening of the hernial sac from the outside, since this would provide far better exposure during reposition of the contents. For this purpose the transabdominal approach introduced by Harrington is rather inadequate. However, adhesions between the stomach and the contents of the hernial sac are so rare in the case of para-esophageal hernia that they may be ignored for practical purposes.

In our view, it is perfectly permissible to leave the hernial sac in position, provided one closes the hiatus no further than is necessary to permit any exudate to pass into the abdominal cavity. Recurrence of the hernia can be effectively prevented *by suturing the stomach to the anterior abdominal wall.*

We have, in fact, first performed *gastropexy* in para-esophageal hernia—as it happened, as an emergency measure. The patients in question were elderly subjects in poor general condition as a result of a state of incarceration lasting several days. The stomach was then drawn down into the abdomen through a small laparotomy incision, the strangulation marks sutured over, and the stomach then attached to the anterior abdominal wall, to obviate any slipping back into the hernial sac, which remained untouched.

Follow-up of these patients five years later showed complete normality of the situs of both stomach and cardia and *total absence of any undesirable effects. With this, the indication* for gastropexy as an elective measure was extended to those cases of para-esophageal hernia which—either because of the advanced age of the patient or because of other severe disease (e.g., cardiovascular, renal, or respiratory insufficiency)—seemed unsuitable for either transthoracic operation or abdominal hernioplasty on the lines advocated by Harrington.

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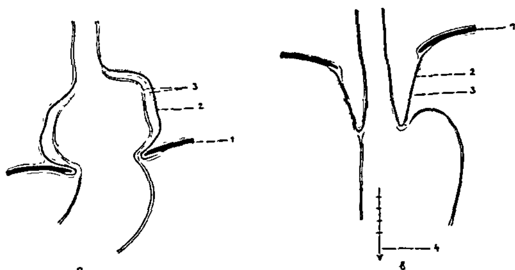


Fig. 1. Scheme of downward displacement and eversion of hernial sac in sliding esophageal hernia treated by gastropexy.

a, Situs before the operation
1. Diaphragm
2. Mediastinal pleura
3. Hernial sac

b, After the operation
1. Diaphragm
2. Phrenico-esophageal ligament
3. Everted hernial sac
4. Sutures fastening lesser curvature to anterior abdominal wall

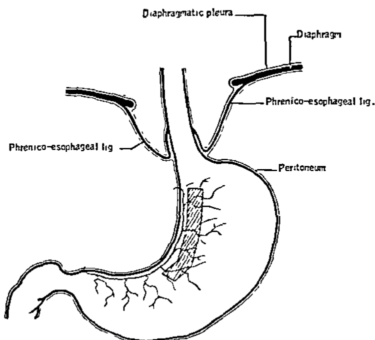


Fig. 2. The area of lesser curvature fastened to the anterior abdominal wall in sliding hernia is marked.

The intervention is a minor one, can be performed in a short space of time, and affords the surgeon ample maneuvering space for additional interventions in the upper abdomen.

Apart from a sensation of tension in the region of the incision which occurs in some patients and lasts for two or three weeks, the immobilization of the lesser curvature involves no undesirable consequences, so far as our experience carries us to date.

Technique of Gastropexy

In Sliding Hiatal Hernia (Figs. 1 to 4)

For *incision of the abdominal wall,* we use the sinistral paramedian incision in the absence of cholelithiasis and the dextral paramedian incision where cholelithiasis is present. The incision begins at the costal arch and ends in the umbilical region. In order to have the posterior sheath of the rectus abdominis easily available for purposes of gastropexy, it should be incised at a point about 3 cm. from the median line. Once the abdominal cavity is opened, the hiatus oesophageus, its breadth and the peritoneal protrusion extending mediastinally is palpated. In addition, stomach and duodenum should be examined for a possible peptic lesion, likewise the gallbladder and the sigmoid flexure. In the event of cholelithiasis, the biliary tract operation should be performed *prior to* gastric intervention.

For gastropexy, the stomach should be gripped along the side of the *lesser curvature* with three clamps, placed at intervals of 4 cm. along the axis of the stomach. Powerful traction is then exerted on the uppermost clamp so that one can confirm by palpation that the peritoneal protrusion is everted and the cardia and upper part of the stomach are tautly tensed. This not inconsiderable traction exerted on the clamp is retained throughout the execution of the gastropexy. The uppermost clamp is not removed until it is replaced by a strong silk suture uniting a broad fold of the stomach in the region of the lesser curvature with the highest point of the left lip of the divided posterior sheath of the rectus abdominis. The tension is maintained by traction on the remaining two Allis clamps. Five to seven sutures at 2-cm. intervals are then sufficient to insure dependable fixation to the anterior abdominal wall as far

terior sheath of the rectus abdominis. To insure this, the sutures which close the latter are so placed that they lie between the sutures made for the gastropexy. Drains—extending, in the case of simultaneous cholecystectomy, as far as the stump of the gallbladder—are passed through a separate incision.

The anterior sheath of the rectus abdominis is sutured with alternating stitches of silk and chrome catgut or with fine wire.

The Levin tube remains in the stomach for twenty-four hours. By the third day after operation, patients are able to get up. By the tenth to twelfth day, the average patient is ready to leave the hospital.

In Para-esophageal Hernia (Figs. 5 and 6)

In the case of para-esophageal hernias, even those of an extensive nature, we seldom see any indication for the transthoracic approach today. Particularly in elderly patients, our method of choice is gastropexy, combined—provided it presents no difficulty—with transabdominal narrowing of the hernial orifice by means of individual silk sutures. In this type of hernia, the cardia usually is in the normal position. The draw-

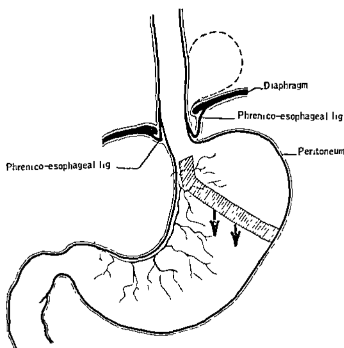


Fig. 5. The area of the anterior wall of the stomach fastened to the left subcostal arch in para-esophageal hernia is marked Broken line: hernial sac.

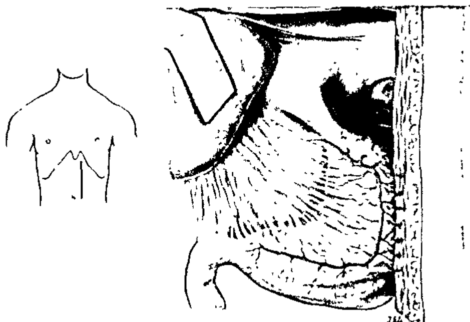


Fig. 3 Diagrammatic scheme of gastropexy in sliding hiatal hernia. The region of the lesser curvature is fastened to the posterior rectus sheath. *Insert,* Abdominal incision



Fig. 4. A, X-rays of sliding hiatal hernia. *B,* X-ray three years after gastropexy.

down as the *angulus ventriculi.* It is surprising that the considerable traction to which the upper part of the stomach remains subjected should occasion no long-term disorders.

Great care must be taken to avoid postoperative hernia. For this reason, meticulous care is exercised in closing the pos-

In cases of para-esophageal hernia, we originally fixed the stomach with a pedicled strip of fascia taken from the anterior sheath of the rectus abdominis. However, this proved unnecessarily complicated, and subsequently the method of fixing the stomach including its base, which had proved its worth in sliding hernia, was adopted. Results, both mechanical and clinical, were satisfactory. The operative procedure is as follows:

Starting with a sinistral subcostal incision, the stomach is extracted from the hernial sac and three Allis clamps are placed, the first, as for sliding hernia, high on the lesser curvature, the other two, at approximately 4-cm. intervals, at the fundus, and the whole subjected to traction. Suturing is performed along the line marked by the clamps. Six to eight strong silk sutures pass through the cartilaginous costal arch, the posterior sheath of the rectus abdominis, the parietal peritoneum, and a broad fold of the stomach. The caudal incision of the posterior sheath of the rectus is joined with the cranial incision between the spaces separating the fixation sutures.

The Addition of Fundoplication

In minor cases of sliding hiatal hernia, the marked clinical signs sometimes stand in striking contrast to the insignificance of the x-ray findings; in such cases, one usually finds the predominant syndrome of *reflux esophagitis.* The question then arises as to whether the hernia may be, not the cause, but the result, of esophagitic regurgitation of the stomach contents extending over many years. Where, in such patients, the reflux is identified by x-ray and the esophagitis confirmed by endoscopy, one further intervention is added, which originally was applied only in the pure forms of reflux esophagitis.

This procedure of *fundoplication* has given surprisingly good results. Observation of 96 cases has given the following picture:

1. Para-esophageal hernia plus gastropexy (21 patients)

Observation time:

1 case	12 years
1 case	6 years
10 cases	1 to 3 years
9 cases	less than 1 year

Symptomatic and roentgenological cure: 19 patients (90 per cent)



Fig. 6. *A*, X-ray of upside-down stomach in large para-esophageal hernia. *B*, X-ray after gastropexy.

ing down of the lesser curvature (and hence of the cardia) is less important than fixation of the fundus of the stomach. Once this is firmly fixed, it becomes impossible for the rest of the stomach or for the organs united with it by ligaments (e.g., spleen and colon) to pass into the hernial sac. In the same way, broad suturing of the stomach to the anterior abdominal wall prevents the highly mobile small intestine from gaining access to the hernial sac. From this it follows that closure of the hernial orifice is not absolutely essential. In two cases of strangulated para-esophageal hernia treated more than ten years ago, gastropexy was performed without closure of the orifice, owing to the advanced age and poor general condition of the patients concerned. One of these patients, a physician, is still active today at the age of 79; the other died six years after the operation in question from metastasizing cancer, apparently originating in the prostate (no postmortem examination was performed, since the patient died at his home). In neither case were there any clinical or roentgenological findings that could reasonably be ascribed to the fact that the hernial orifice was left intact.

Where the hernial orifice is closed and the hernial sac left in place, a hydrocele-like process develops, which would seem gradually to undergo spontaneous obliteration.

Fig 9. *A*, Small sliding esophageal hernia with severe reflux esophagitis. *B*, Status 2½ years following fundoplication plus gastropexy. No more reflux; no complaints.



Fig. 10. *A*, "Malposition cardiofundal" with severe reflux esophagitis. *B*, Following fundoplication. No more reflux, no complaints.

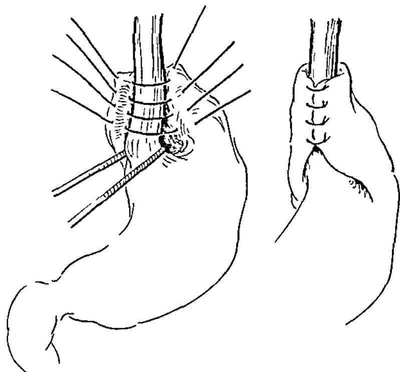


Fig. 7. Scheme of fundoplication in reflux esophagitis.

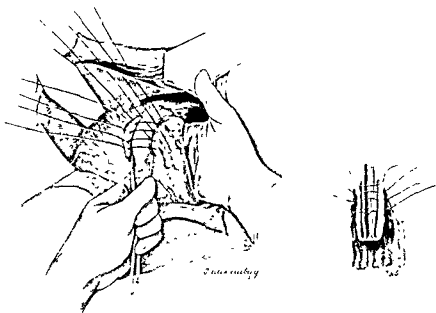


Fig. 8. Fundoplication for reflux esophagitis The abdominal cavity is opened through a left subcostal incision The lower esophagus is mobilized and put on tension after incision of the diaphragmatic peritoneum The fundus of the stomach is wrapped around the lower esophagus and anterior and posterior walls of the fundus are united by four sutures In order to prevent undue narrowing of the esophagus, a heavy gastric tube is left in the esophagus during the procedure

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One recurrence due to poor technique
One very small fundal prolapse without clinical symptoms

2. Sliding hiatal hernia plus gastropexy (as lone procedure) (40 cases)

Follow-up time: 3 months to 3 years
Symptomatic and radiological cure: 33 cases (82 per cent)
Recurrence in 7 patients, of whom 4 have only radiological signs but no clinical symptoms
Two cases with clinical and radiological symptoms
One case with clinical symptoms but normal x-ray findings

3. Reflux esophagitis on the basis of sliding hernia (27 cases) and "malposition cardiotubérositaire" (8 cases) treated by fundoplication

Follow-up period of 3 months to 3½ years
Symptomatic and radiological cure in 33 cases (94 per cent)
Recurrence in one case due to separation of plicating sutures
One case asymptomatic, but radiological recurrence

Overall results of gastropexy and fundoplication in the different pathological conditions of the cardiohiatal region were:

Symptomatic and radiological cure in 85 of 96 cases (88 per cent)
Asymptomatic radiological recurrence in 7 cases

*Consequently, in 96 per cent all complaints referable to the cardiohiatal condition have disappeared.**

Conclusion

Gastropexy is in *para-esophageal hernias* of poor-risk patients a safe and reliable procedure to correct and prevent intestinal prolapse and strangulation. In *sliding hiatal hernia* gastropexy seems according to our experience to be superior to any form of hernioplasty. In cases of small hiatal hernia complicated by reflux esophagitis, an additional fundoplication is able to prevent further regurgitation of gastric content into the esophagus.

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* At the time of proofreading (two years after completing the preceding statistics) the number of cases has increased as follows:

[illegible] 35 cases
[illegible] 71 cases
[illegible] the reflux syndrome . . . . . 113 cases
TOTAL . . . . 219 cases

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Transthoracic Repair of Hiatal Hernia

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The Cleveland Clinic Foundation and
The Frank E. Bunts Educational Institute

Hiatal hernia is just one other form of coelomic herniation. It is unique because the herniated viscus usually is the stomach. The mechanism of herniation is identical to that of most of the other types of acquired coelomic hernias—a weakening or a relaxation of supporting tissues in addition to persistent intra-abdominal pressure. The most common symptom of hiatal hernia is pyrosis that occurs after meals and in recumbency. The complications of hiatal hernia are related also to the gastric mucosa and its ectopic position above the diaphragm. The most frequent complications are ulceration, bleeding, and obstruction by stricture at the esophagogastric junction.

Medical literature is encumbered with verbose reports on the subject of hiatal hernia. Many of the papers were written by internists, gastroenterologists, and radiologists, and the basic problems of hiatal hernia are submerged in trivia, irrelevant detail, erroneous concept. From this welter of material have evolved elaborate classifications and remarkable terminology that contribute to the confusion involving a subject that is basically simple. Needless to say, the majority of medical programs recommended for treatment of symptomatic or complicated hiatal hernia are as ineffectual as those that might be applied to other types of coelomic herniation. The basic problem is an anatomic derangement—correct this derangement surgically and the problem is solved.

Classification

From the surgeon's point of view there are two basic forms of hiatal hernia: (1) the *pulsion type*, in which the motivating

force is the intra-abdominal pressure exerted against a naturally weak point in the diaphragm—this includes the so-called "para-esophageal," "perihiatal," and the "sliding type" of hernias; (2) the *traction type*, in which the gastric component is drawn into the mediastinum by contraction of the esophagus—this herniation is usually referred to as the "short esophagus" type and comprises about 10 per cent of all.

Operation

Principles

In any operation for coelomic hernia the basic objective is the permanent reduction of the hernia with minimal risk to the patient. This can be accomplished in carefully selected patients when the general surgical principles of hernial repair are followed: (a) complete dissection of the involved structures, (b) removal of any sac element and, (c) proper anatomic reconstruction of the involved area.

When these principles are properly applied, the stomach is permanently reduced below the diaphragm and a normal esophagogastric function is re-established. The objective then is accomplished.

Transthoracic Repair

Surgical correction of hiatal hernia is readily obtained when the transthoracic approach is employed. This is applicable to all types of hiatal hernia, regardless of existing complications or a short esophagus. The five basic structures involved in dissection and repair of the hiatal hernia are: (1) the esophagus and its accompanying vagus nerve, (2) the thoracic stomach, (3) the hiatus with its respective crura, (4) the phreno-esophageal ligament, and (5) the underlying reflected peritoneum which is the sac element in this form of hernia.

Each of these structures is accessible through the left side of the chest, regardless of the patient's weight or previous operations. Utilizing this excellent exposure, the surgeon may carefully expose and dissect each structure in proper turn. After complete mobilization of the terminal esophagus and protection of the vagus nerves, the thoracic stomach is freed within its

mediastinal compartment. The crura of the hiatus are completely exposed and are relieved of superfluous areolar tissue. The preliminary dissection is completed when the phreno-esophageal ligament and its underlying reflected peritoneum are incised and trimmed around the muscular sling of the hiatus from the lesser to the greater curvature of the stomach. It is a relatively simple matter to reduce the stomach below the diaphragm, unless there is a significantly shortened esophagus. Permanent reduction is obtained by anchoring the proximal, cut end of the phreno-esophageal ligament to the inferior surface of the diaphragm with multiple silk sutures. The hiatus is partially closed by approximating the right and the left crura posteriorly to the esophagus.

With this simple technique the basic principles of hernial surgery are satisfied: a careful dissection of the involved structures is made, the sac element is eliminated, and practical reconstruction of the esophageal hiatus is obtained. Should there be a shortened esophagus, satisfactory results usually will be accomplished by the addition of permanent phrenic paralysis and advancement of the esophageal hiatus to the tendinous dome of the diaphragm.

Comment

It is a human trait to seek the easiest way out of any situation—this is apparent whenever poorly conceived surgical "short-cuts" are substituted for a proven procedure. Operations for hiatal hernia have included phrenicotomy alone, fixation of the stomach to the anterior abdominal wall, enlargement of the esophageal hiatus, even removal of large fibroid uteri to reduce intra-abdominal pressure. Those who advocate such measures never would apply them to other types of abdominal hernia—at least I cannot believe that they would. Such poorly conceived operations would be justified only on grounds of their ultimate success and if there has been success, it has not been apparent from published follow-up studies. A surgeon who sponsors an operative procedure should be prepared to present favorable results in a follow-up series of statistical significance.

I am well aware that competent surgeons can perform adequate hernial repairs in a high percentage of cases utilizing the abdominal approach. Whenever the objective has been accom-

plished, the method employed is considered to be good. However, the fact remains that all hernias are not amenable to that approach, particularly those associated with the short esophagus. Also, I have the impression that the incidence of recurrence of hiatal hernia is greater when the abdominal approach is used—perhaps because of the significant number of grateful patients whose transabdominal failures are now transthoracic successes.

The transthoracic approach, of course, precludes operation upon the gallbladder, the uterus, and other unrelated viscera. This may be offered as an objection, but it applies also to the surgical correction of the other forms of coelomic hernia. It must be remembered that the hiatal hernia that requires correction is a specific disease requiring specific therapy. It should not be part of a "grab-bag" type of operation with which additional, even unplanned, intra-abdominal procedures are included.

Repair of hiatal hernia by the transthoracic route is safe. Since 1949, my associate, Laurence K. Groves, and I have used the technique described above in more than 400 operations for all types of hiatal hernia. Two patients died: one of acute coronary infarction ten days after operation, the other of mediastinitis secondary to unrecognized esophageal perforation.

The Abdominal Repair of Esophageal Hiatal Hernia

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General Considerations

Surgical correction of esophageal hiatal hernia and its complications has become increasingly popular during the past decade. Increased knowledge of these problems and of esophagitis in general justify this enthusiasm. Hiatal hernias of the sliding, para-esophageal and composite types are well defined.[1, 2, 12] A congenitally short esophagus with thoracic stomach that cannot be brought below the diaphragm is unusual and is not in the true sense a hernia. An esophagus whose lower segment is lined with gastric mucosa, sometimes as high as the aortic arch, may be associated with a sliding hiatal hernia well below the junction of the squamous and glandular epithelium. All types of hiatal hernias may be associated with reflux esophagitis or gastric ulcer and their complications. Much still remains to be clarified concerning the complex interrelated sphincter mechanisms of the lower esophagogastric segment as well as the production of symptoms in patients with hiatal hernia.[10] Surgical measures have, however, been placed on a much firmer anatomic and physiologic basis.

Indications for Surgical Therapy

The indications for surgical repair of a hiatal hernia are the presence of symptoms that prevent the patient from living a normal, comfortable life. Patients should not be continued on partially effective palliative medical measures consisting of special diets, antacids, sleeping in semi-upright positions, etc., for

prolonged periods. This has been the case too often in the past. It is especially unwise if the hernia is large.[11] There is no medical therapy in the strict sense for a hernia. This is a progressive disorder with potentially serious complications.[5] In assuming this attitude it is important to remember that all esophageal hiatal hernias are not symptomatic. Some, in fact, may be temporary, as in infancy, during pregnancy, and in obesity. Symptoms are not specific. Further, the casual "stitching up" of every minor hiatal ring enlargement encountered during laparotomy for other causes is to be condemned. Harm may result and little if any good is to be accomplished unless a definite hernia is present which is symptomatic. Evidence indicates that a large asymptomatic hernia should be an exception to this general rule.[11]

The Surgical Repair

An Allison type repair[1] with or without modifications or additions is the operation enjoying greatest popularity for the correction of esophageal hiatal hernia. Basically this procedure eliminates the hernia sac, reapproximates the separated muscle fibers of the right crus of the diaphragm posterior to the esophagus, and anchors the lower esophageal segment to the subdiaphragmatic fascia about the margin of the hiatus.

Elimination of the hernia sac is of prime importance in any hernia repair. Excision is preferable. Plication may suffice in small hernias.

Reapproximation of the separated muscle bundles of the right crus posterior to the esophagus restores their normal relationship and closes the hiatus about the esophagus to prevent upward displacement of the stomach. The hiatal muscle ring, which ordinarily is formed entirely from muscle fibers of the right crus, enlarges with a hiatal hernia because the fibers separate posteriorly along the line of least resistance. For this reason suture repair should be made posterior to the esophagus, not anteriorly or laterally. The resulting repair is anatomically correct and the weak area is reinforced to prevent future separation. The slinglike relationship and action of the crus about the esophagus is re-established. Upon contraction the crus will draw the esophagus inferiorly and posteriorly as well as exert lateral compression.

Anchoring the lower esophagus to the subdiaphragmatic fascia reconstitutes the phreno-esophageal ligament action. This resists upward displacement and allows limited mobility between the esophagus and diaphragm.

The preceding maneuvers of repair indirectly restore the normal acute angle of entrance of the esophagus into the stomach. Flap valve action of the gastric mucosa just distal to the esophagogastric junction is also regained.[2] The overall restoration of more nearly normal anatomic relationships of the lower esophagus, diaphragm, and stomach favors proper physiologic function. Symptoms are controlled in the vast majority of patients. The recurrence rate is low.

The Surgical Approach for Hiatal Hernia

The surgical approach to accomplish the repair of a hiatal hernia has been a subject of much controversy. That this operation can be performed with a very low mortality and with quite successful results using either an abdominal or a thoracic approach is attested in numerous publications.[2,3,5,8,14] In some discussions of the subject this important decision is lightly left to the "preference of the surgeon"; in others, one surgical approach is vigorously championed to the exclusion of the other. It is the opinion of the author that the operating surgeon should be thoroughly familiar with either approach and apply without bias the most advantageous one for a particular patient rather than fit the patient to the operation. Sound surgical judgment permits neither an abdominal nor a thoracic approach to be applied routinely. At the University Medical Center our initial applications of the Allison operation were limited to the thoracic approach. Increased experience leads us to conclude, however, that the great majority of patients requiring repair of a hiatal hernia will be best served by utilizing the abdominal route.

Contraindications to the Abdominal Approach

Severe esophagitis with advanced stricture formation, esophagus lined with gastric mucosa, congenitally short esophagus, and short esophagus secondary to esophagitis and to stricture require in most instances a thoracic or thoraco-abdominal

approach for surgical correction. More radical procedures than simple hernia repair are necessary. The presence of these conditions can be determined or strongly suspected by thorough preoperative studies which should include esophagoscopy routinely as well as roentgenologic examination. The former is especially helpful in determining the level of junction between squamous and glandular mucosa. This may be well above the expected location from external examination of the esophagus and stomach at operation. Ordinary hernia repair in such a situation can complicate the problem particularly if any tendency toward impaired drainage of the gastric lined esophagus results from narrowing the hiatus. The conditions favoring esophagitis or gastric ulcer are enhanced. We had this complication in one patient in our series before these facts were fully appreciated. A severe esophageal stricture resulted. This necessitated a second procedure at which time the stricture was resected and a jejunal interposition operation was performed. Esophagitis can also be objectively studied best by esophagoscopy. A biopsy can be taken of any lesion arousing suspicion of malignancy.

A concomitant pathologic condition in the chest remediable by surgical attack would also favor a transthoracic operation for its correction at the time of hernia repair.

Advantages Afforded by an Abdominal Approach

The advantages afforded by the abdominal approach are diagnostic, technical, the correction of concomitant pathologic conditions, and the possible reduction of operative and postoperative complications, morbidity, and mortality.

Diagnostic Advantages

The diagnostic advantages of the abdominal approach revolve around the correlation of symptoms present with the pathology present. Symptoms produced by hiatal hernia are not diagnostic. Harrington's[7] admonition that hiatal hernia can be the great masquerader within the abdomen is also true in a reverse sense. Other pathologic conditions amenable to surgical treatment and mimicking the symptoms of hiatal hernia when present are usually located within the abdomen. Inten-

sive preoperative studies may occasionally fail to disclose such associated disorders or be inconclusive in excluding them. A duodenal irregularity or spasm without an ulcer niche, a gastric irregularity, questionable malfunction, and stone of the gallbladder are good examples. The etiology of hematemesis or melena can be quite confusing. We have encountered one entirely unsuspected antral carcinoma of the stomach.

An abdominal incision offers a wide field for thorough visual and palpatory exploration, much more satisfactory than is obtained transthoracically through a separate diaphragmatic incision with the patient in a lateral recumbent position.

Technical Advantages

A left paramedian abdominal incision is a simple incision that can be opened and closed rapidly. An extension of the incision to split the sternum has not been necessary in our experience. No large muscle masses are cut across. Bleeding is minimal. A dorsal recumbent position minimizes respiratory effort during anesthesia. The adverse physiologic effects of an open chest with a partially collapsed lung and a lateral position under anesthesia are eliminated.

Reflection medially of the left liver lobe after incising its suspensory ligament gives excellent exposure. The hiatus and the entire right crus, whose origin extends as low as the third and fourth lumbar vertebrae, are completely visualized. The repair of the crus can extend to its most inferior extent under direct vision. Often only the superior portion is as readily available transthoracically. Occasional variations of the muscle mass[9] forming the hiatal ring are more readily recognized and, if necessary, adjustments in surgical technique can be easily instituted.

The herniated sac and organs are more readily reduced into the abdominal cavity and are maintained more easily in the abdomen during the hernia repair by traction downward, than by pushing from above. In fact, this means of maintaining reduction is sometimes advisable during a transthoracic repair, utilizing an incision in the diaphragm. A separate diaphragmatic incision for technical aid or exploration (through which a postoperative hernia has been known to occur) is averted with a transabdominal approach.

Modifications and additions to the basic operation, such as pyloroplasty,[6] suture fixation of the acute angle of entrance of the esophagus into the stomach,[2] vagotomy or combinations,[4] probably all have some place in the treatment of selected patients with the complications of hiatal hernia. These are more readily accomplished using an abdominal approach.

Correction of Concomitant Pathologic Conditions in the Abdomen

When such conditions are remediable by surgical means, their correction is indisputably best achieved transabdominally. At least 25 per cent of patients whose symptoms from hiatal hernia demand surgical attention have concomitant abdominal disease which is recognizable preoperatively.[3, 13] Gallbladder disease is especially prevalent. Recognition of such additional affections preoperatively demands an abdominal approach. Failure to be able to rule out this possibility in a clear-cut fashion should affect the decision similarly. The occasional surprising discovery of such a lesion at laparotomy in spite of negative intensive preoperative studies leads us to use the abdominal approach unless there is a definite contraindication.

Reduction of Operative and Postoperative Complications, Morbidity and Mortality

The more accurate diagnosis and correction of associated pathologic conditions allowed by an abdominal approach may reduce operative and postoperative complications, morbidity and mortality. We are aware of one patient's postoperative period being complicated by a flare-up of acute cholecystitis when a thoracic approach was elected in spite of preoperative evidence of gallbladder disease with stones.

The majority of patients with hiatal hernia demanding surgical intervention fall into the older age groups. Many have associated cardiac disease, emphysema, and other degenerative diseases that increase surgical risk. It is our impression that an abdominal procedure is tolerated better in these patients. The occasional postoperative accumulation of pleural fluid, hemothorax, or failure of lung expansion even when underwater-seal drainage is used is averted. This is more apt to occur when

the diaphragm is incised at operation or when there has been previous pleural disease. Postoperative wound pain is less. The patient is better able to cooperate. Nursing care is less complicated. Convalescence in general is hastened.

Summary

Surgical correction of esophageal hiatal hernia utilizing an Allison type of repair can be satisfactorily accomplished either transabdominally or transthoracically. Each approach has its inherent advantages and disadvantages. The surgeon should be familiar with both methods and select the operation for a given patient on an individual basis. To do otherwise is to ignore basic principles of sound surgical judgment. Our experiences at the University Hospital lead us to conclude that the abdominal route offers the most advantages for the majority of patients requiring surgical repair of a hiatal hernia.

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The Choice of Operation for Carcinoma of the Head of the Pancreas

Introduction

The controversy over the proper operative procedure for carcinoma of the head of the pancreas has waxed and waned. When it was demonstrated in 1935 that radical excision of the head of the pancreas was a feasible operation, hopes were high that cures of carcinoma in the pancreas would follow. This was not to be so, however. There were so few five-year survivors that many surgeons abandoned attempts to remove the tumor, reasoning that results of palliative operations matched those of resection. In recent years there have been more encouraging reports of radical duodenopancreatectomy in selected cases. Controversies have arisen around methods of selection, biopsy techniques, the significance of negative biopsy and means of distinguishing whether the tumor is ampullary or pancreatic.

There is agreement at the moment that, when regional nodes are invaded by tumor, no radical operation should be attempted. This means that only a few eligible cases are encountered.

The two discussions which follow present current ideas about the question.

J. H. M.

Treatment of Pancreatoduodenal Carcinoma by Radical Duodenopancreatectomy

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When Whipple introduced radical resection of the head of the pancreas for carcinoma, it was not known whether or not any of these patients could be salvaged for five years or longer. There were a number of years of discouragement, and the number of five-year survivors of carcinoma of the head of the pancreas remains small.

Factors Influencing the Choice of Radical Resection

It is not always possible at operation to say whether a carcinoma in this area arises primarily from the pancreas and invades the bile duct, or whether it arises in the bile duct or even the ampulla of Vater and invades the pancreas. Likewise, carcinomas may arise in the adjacent duodenal wall and invade adjacent pancreas and bile duct. Thus, if one adopts the attitude that he will not attempt a radical surgical cure in a case of carcinoma of the head of the pancreas, he is likely also to exclude from possible operation many of the other carcinomas in this area arising from the bile duct, the papilla of Vater, and the adjacent duodenal wall. He will be able to distinguish a few which remain more or less localized in the papilla. We have come to believe, therefore, that at the clinical level, which is after all the level at which the decision has to be made, these four tumors should be considered together and a uniform program of treatment devised for them.

One of the major difficulties for the surgeon who is pre-

pared to do the Whipple operation is to satisfy himself regarding the diagnosis of carcinoma at the operating table without *spreading the lesion. Virtually all of these patients have obstructive* jaundice, and exploration of the common duct generally shows no stones and shows that the lower end of the duct is occluded so that passage of a probe cannot be satisfactorily accomplished or can be done only with extra force. A mass is routinely palpable in the head of the pancreas but may not be at the papilla of Vater. Usually the duodenum is then opened and the papilla inspected. If there is no evident carcinoma there, a needle biopsy may be attempted from within the *lumen of the duodenum.*

When this procedure is completed or when an actual biopsy of a tumor of the papilla is taken, the duodenum is closed and the instruments used to handle the malignant tissue are discarded.

Whether or not tumor tissue is obtained, I believe that the surgeon is justified in proceeding with a radical procedure if he is convinced that tumor is present. Some clinicians take exception to this view, feeling that a *histologic diagnosis must be* established to justify so dangerous a procedure. Open biopsy of the head of the pancreas from outside the duodenum would appear to carry a significant risk of spreading the tumor. For the same reason needle biopsies obtained from outside the lumen seem less desirable than those done transduodenally.

Owing, perhaps, to associated inflammatory changes in the head of the pancreas, we have found biopsy methods unreliable unless positive. In a series of patients who were believed on the basis of the gross appearance to have carcinoma but who had shunting operations only, without resection or biopsy, four of 60, or 6.7 per cent, survived over five years. We believe that these individuals did not have carcinoma and that this may represent the approximate error in the gross clinical diagnosis at operation. There are few cases in the literature in which a Whipple operation has been done and the diagnosis not confirmed. Most of these patients have survived the procedure.

On balance, therefore, whether one insists on a histologic diagnosis before proceeding with resection would seem to depend on the reliability and safety of the sampling technique.

Operative Steps

Once a decision has been reached to treat the patient for pancreatoduodenal carcinoma, pancreatoduodenectomy is carried forward about as follows:

(1) The hepatic flexure of the colon is reflected downward and to the left, exposing all of the transverse portion of the duodenum and the region of the uncinate process of the pancreas.

(2) The duodenum and the head of the pancreas are mobilized.

(3) The superior mesenteric vessels are then found and traced upward to the point at which the superior mesenteric vein passes behind the neck of the pancreas where the splenic vein joins it to form the portal vein. An effort is made to ascertain whether the superior mesenteric or portal veins are invaded by tumor.

(4) Enlarged lymph nodes in the area which frequently occur along the common duct are generally biopsied and frozen sections are done on the most suspicious ones. If the vein is not invaded and there is no clinically evident metastasis in the liver or in the local nodes, the case is considered a suitable one for a radical resection of the Whipple type. Unfortunately, one usually excludes 70 to 90 per cent of the cases with this decision because the disease is already too far advanced.

For the smaller group of cases not so excluded, however, the operation proceeds with (5) division of the common bile duct above the duodenum; (6) division of the proximal jejunum; (7) mobilization of enough jejunum distally so that the distal end can easily be brought up to the common bile duct; and (8) mobilization of the proximal end of the jejunum and the duodenum. An effort is made (9) to resect adjacent portions of the gastrohepatic and gastrocolic omenta, and (10) the stomach is divided at about its midpoint. The pancreas (11) is generally divided about opposite the spinal column and carefully dissected away from the portal vein with (12) ligation of the small tributaries extending between the organ and the vein. The uncinate process likewise (13) must be rather carefully dissected away from behind the vein, and the specimen can then be removed by (14) division of the rest of the duodenal blood supply.

After the specimen is resected, several methods may be

used for re-establishing the continuity of the alimentary tract and of the biliary tract, and of the flow of pancreatic juice from the remaining pancreas. Perhaps the most direct method is to draw the jejunum up antecolically and (15) to do either an end-to-end anastomosis of the jejunum to the dilated common duct or, if this is awkward, to close the end of the jejunum and anastomose the end of the common duct to the side of the jejunum close to its end. Unless the common duct is quite large, it is our usual practice to protect the lumen of the anastomosis either with a T-tube or a catheter. The pancreatic duct can then (16) be anastomosed end-to-side to the jejunum. The introduction of a small catheter into the pancreatic duct serves as a stent to keep the pancreatic duct open, and it (17) may be brought out through the wall of the jejunum at another level to the abdominal wall for continuous suction in an effort to remove pancreatic juice, which if it becomes activated by jejunal juice, may lead to a process of autodigestion.

(18) The capsule of the pancreas is then sutured to the wall of the jejunum and (19) a gastrojejunostomy of the Polya or Hofmeister type is done somewhat further distally on the jejunal segment. (20) Drains are placed in the subhepatic space. (21) Cholecystectomy is usually done unless the gallbladder is needed for anastomosis. If it is left, one must be sure that the cystic duct still communicates freely with the common hepatic duct.

Evaluation of Results

The chief drawback of the operative procedure is the mortality, which in many series has run about 25 per cent, though in a few series it has been reduced to less than 10 per cent, and in the series of Mr. Rodney Smith, 33 consecutive cases are reported without a death.

The procedure is obviously a long and difficult one which taxes the vitality of both the patient and, in a different sense, the surgeon, but the particular pitfall seems to surround the pancreatic anastomosis. There are those, such as Brunschwig, who believe that it is better simply to ligate the pancreatic duct and not to attempt any anastomosis of the pancreatic ductal system to the small bowel. This, however, does not necessarily get away from the problem entirely, as pancreatic juice may

leak from the cut surface of the pancreas. Others have suggested total pancreatectomy. This, of course, leaves the patient diabetic, and it has not as yet reduced mortality in any series of cases which we know about.

For the present, we must evaluate the Whipple operation in terms of actual mortality experience, even though there is every reason to believe that the mortality will be brought down to perhaps a third of current levels as greater experience is gained.

In the cases reported by Zintel, Helwig, and the author from the Hospital of the University of Pennsylvania, the five-year survivors constituted 26 per cent of patients subjected to operation. One may easily say that there is little to be gained by an operation which saves only 26 per cent of patients if the mortality is 26 per cent, but a little thought will, I believe, indicate that this is not a logical conclusion. Without operation, there is reason to believe that all of these patients die, and in our experience they die fairly soon. Indeed, the average life expectancy for all patients with pancreatoduodenal carcinomas seen in this hospital since 1941, in whom a histologic diagnosis was obtained but in whom radical resection was not attempted, was 8.5 months. Granted that the more favorable cases are selected for operation and that these patients would live somewhat longer, there is little reason to believe that many of them will survive a long period without therapy. Including the operative deaths, the average survival for those having the Whipple operation in the series from this hospital is already up to 30.5 months, or between three and four times as long as those individuals having palliative procedures.

Summary and Conclusion

The previously reported experience from this hospital leads to the following statements:

1. Of all patients with pancreatoduodenal carcinoma, those deemed suitable for operative intervention constituted only 26 per cent.

2. In those undergoing the operation, the mortality is still quite high, reaching between 20 and 30 per cent in a number of series.

3. The life expectancy of patients who did not have radical

TABLE 1. FIVE-YEAR SURVIVORS OF WHIPPLE OPERATIONS FOR PANCREATODUODENAL CARCINOMA COMPILED FROM THE LITERATURE

Author and Year	*Head*	*Ampulla and Papilla*	*Duodenum*	*Common Duct*	*Location Not Stated*	*Total*
Orr, T. G. (collected series), 1952	3	11			2	16
Muir, E. G , 1955	1	1				2
Dennis and Varco (collected series in addition to Orr's), 1956.	8	3	1		1	13
Smith, R., 1956.	1	3	2			6
Ross, D E., 1957	1					1
Rhoads, Zintel, and Helwig, 1957[1]		2	1	3		6
Waugh and Giberson, 1957	3	5	2			10
Case added from Hospital of the University of Pennsylvania		1				1
TOTAL CASES	17	26	6	3	3	55

TABLE 2. PANCREATODUODENAL CARCINOMA, HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA—1958[2]

Whipple resections carried out before 3/1/53		27
Follow-up		
Operative mortality.	7 (26%)	
Five-year survivors	7 (26%)	
Average Survival up to 3/1/58		
Whipple resections (27 cases)		.30.5 Mos
Shunting procedure only—no resection (22 cases)		11.0 Mos.
Laparotomy—no resection or shunt (9 cases).		2 5 Mos.

resection, but who had shunting operations or laparotomy, was only 8.5 months. The survival of those who had the procedure is already 30.5 months.

4. Of the patients undergoing radical pancreatoduodenectomy for pancreatoduodenal carcinomas, 26 per cent lived five years or longer.

Therefore, in patients who do not have really strong contraindications to operation and in whom there is no gross evidence of metastasis, radical pancreatoduodenectomy is recommended as a procedure which appears valuable on a palliative basis and as a procedure which affords the patient perhaps as

good a chance of cure as he could expect with carcinoma of the midportion of the stomach, and a result definitely better than that usually obtained with carcinoma of the gastric fundus or carcinoma of the esophagus.

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Palliative Procedures for Carcinoma of the Head of the Pancreas

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Palliative procedures assume an important role in the management of malignant lesions in the region of the head of the pancreas. Both jaundice and pain require relief. The comfort to the patient resulting from simple biliary bypass procedures justifies the surgical risk. Unfortunately, less than one-fifth of these tumors can be resected. Furthermore, in at least a third of these patients, even a palliative biliary shunting procedure will not be feasible at the time of operation. For these reasons at least four factors must be considered in determining the palliative procedure of choice. These include the origin of the lesion, the extent of its spread, the presence or absence of jaundice, and the surgical risk involved. From an evaluation of these factors, the surgical procedures can be outlined and the results compared with surgical resection.

Origin and Extent of Tumor

The specific origin of the tumor producing biliary obstruction is important. Often all periampullary carcinomas are considered together. At the time of operation a more accurate diagnosis will be helpful since only those lesions of the ampulla of Vater or duodenum give really satisfactory five-year survival following resection. From a practical standpoint, a preoperative diagnosis of tumor origin must be based on statistics, the pancreas being the most likely site. Approximately 80 per cent of the malignant lesions producing biliary obstruction for which palliative procedures or curative resection can be performed will arise in the pancreas, lower common bile duct, or be

metastatic from the gastrointestinal tract. Only 12 to 15 per cent will arise in the ampulla of Vater. The remainder will be primary duodenal lesions.

The extent of tumor spread must also be considered. Unfortunately, most often the lesion is not resectable with any hope of cure. The primary site may not be obvious even at the time of surgical intervention. The adjacent involved structures are therefore important in determining the palliative procedure to be utilized. If the gallbladder is either the primary site of the tumor or is involved by local or metastatic spread, it cannot be used for a biliary shunting procedure. If the lower end of the common bile duct is involved by tumor, the gallbladder usually serves best for a shunting procedure. If the common hepatic duct is involved, relief of jaundice may be obtained only by passing a firm tube through the tumor.

An adequate biopsy should be made to prove the presence of malignancy even when curative or palliative procedures are not possible. A fistula is rare following liberal biopsy of pancreatic tumors. Without a tissue diagnosis, the prognosis cannot be accurately stated. The best surgical procedure may not be used in many cases, and prolonged survivals will raise many doubts in the minds of both the patient or his family and the surgeon.

If the tumor involves only the ampulla, duodenum, lower common bile duct, or head of the pancreas with no spread to other structures or with questionable lymph node spread, radical resection for palliation or cure may be considered. This procedure is not justified when the portal vein and superior mesenteric artery are involved or when cure is obviously not possible. The mortality will offset any life expectancy gained by those who survive. A decision for or against radical surgery must be reached early. The duodenum must be mobilized and the lesser peritoneal sac opened to adequately evaluate extension into the portal or mesenteric vein or involvement of the gastrohepatic or superior mesenteric artery. Involvement of these structures or liver metastases preclude resection of the tumor even for palliation. In tumors arising primarily in the pancreas resection will rarely lead to cure, there being less than 20 reported five-year survivals in the literature. In questionable cases, the risk of pancreatoduodenal resection versus a simple shunting procedure assumes more importance than the anticipated longer palliation with the former procedure.

Risk

The risks of pancreatoduodenal resection and palliative surgical procedures to relieve jaundice both remain high. The relief of the discomforts of jaundice, notably pruritus, justifies a risk in palliative surgery. On the other hand, lengthy surgical procedures which carry a higher mortality and do no more than relieve jaundice are not justified. Only by weighing risk with anticipated results can an improvement in overall survival be obtained.

The most significant factor affecting risk is the tendency of jaundiced patients to develop hypotension with relatively little blood loss. This hypotension may lead to fatal uremia. It is more likely to develop in patients who have lost significant weight and is associated with preoperative blood volume deficits which average approximately 1,500 cc. in patients with obstructive jaundice due to malignancy. Meticulous replacement of preoperative blood volume deficits and of operative blood loss is very important. Renal function should be good before radical surgery is planned, as evidenced by normal blood urea nitrogen and a urine concentrating power to a specific gravity of at least 1.020.

Several other factors affect risk, particularly in the jaundiced patient. Changes in liver function suggesting liver damage from long-standing obstruction or cholangitis are danger signals. These include a significant elevation of cephalin flocculation or thymol turbidity, a reversal of the albumin/globulin ratio, a lowered prothrombin which fails to respond to vitamin K, and low cholesterol esters. Finally, the age, mental status, general vigor, respiratory reserve, and cardiac status must be considered in weighing radical versus palliative surgery.

Palliative Procedures

In 100 consecutive cases in which palliative or resectional surgery can be performed for periampullary carcinoma, palliative procedures will be necessary in approximately 80 cases. Few of the lesions arising primarily in the head of the pancreas will meet criteria for surgical resection. Generally, the easiest shunting procedure should be chosen in these cases. A

fistula between gallbladder or distended common bile duct and the highest portion of the adjacent gastrointestinal tract is the objective. The use of an en-Roux-Y jejunal loop is unnecessary. This procedure prolongs surgery in critically ill patients. Ascending biliary infection results from an inadequate or stenotic anastomosis more than from reflux of gastrointestinal contents.

When the gallbladder is available for anastomosis and free of tumor, it should be used. Whether the bile is shunted into the stomach, duodenum or jejunum seems to make little difference. Theoretically, a high incidence of peptic ulcer should ensue with the bile diversion into the jejunum, but the short life expectancy decreases the significance of this factor. From a practical standpoint, the easiest enterobiliary anastomosis is usually the procedure of choice. The stomach and duodenum should not be used if tension on the suture line, an extensive mobilization procedure, or subsequent duodenal obstruction is anticipated.

Choledochoduodenostomy and choledochojejunostomy are satisfactory procedures and must be used when the gallbladder is absent or involved by tumor. Usually the common bile duct is greatly enlarged and a side-to-side anastomosis to the adjacent duodenum is more readily accomplished than by other procedures. If the duodenum is involved by tumor or would require mobilization to assure a suture line without tension, choledochojejunostomy should be performed. Only when the patient's general condition is very poor and life expectancy is short, should tube drainage of the common duct or gallbladder be used alone to relieve jaundice.

The routine performance of gastroenterostomy in patients with inoperable carcinoma of the head of the pancreas is not necessary. On the other hand, if obstruction already exists, or if the tumor size, particularly with duodenal involvement, suggests that the patient will survive to suffer subsequent obstruction, gastroenterostomy should be added to the biliary shunting procedure. These are factors which must be determined individually at the time of operation.

Results

The operative mortality for both resection and palliative surgery is high. A mortality for resection has been reported as

low as 4.2 per cent only for ampullary carcinoma. Many reports list only the mortality for all radical resections. This mortality ranges from 11.3 per cent to 53 per cent, averaging well over 20 per cent. This mortality is even higher when resection for carcinoma of the head of the pancreas is separated from radical procedures for other lesions. The mortality for palliative procedures also has a wide range and generally is as high as that for radical resection. This is probably due to the fact that palliative surgery is performed only on the patient in the poorest operative condition. When pancreatic carcinoma alone is considered, the average mortality is lower for palliative than for resectional surgical procedures.

The survivals following resection and palliative surgery as experienced at the University Hospital are comparable to those reported in the literature. Although the prognosis for duodenal, ampullary, and common bile duct carcinoma is better, there are less than 20 five-year survivals reported in the literature after resection for pancreatic carcinoma. The average reported survival following surgical resection is eighteen months, ranging from nine to thirty months. The average survival following palliative surgery varies from only three and one-half to nine months, averaging five months. On the other hand, mean survivals become of more significance than average survivals. The inclusion of occasional long-term survivors will raise the average survival but will not significantly alter the mean survival rate. The mean survivals are therefore only thirteen months for resection and six months for palliative procedures. While the mean survival is greater when resection is performed, this is obviously due to the fact that resection can be best performed on the slower growing lesions, usually those of the common bile duct and ampulla. Extending the indications for resection will increase operative mortality and lower the mean survival. The total survivals therefore may be decreased.

Summary

Palliative surgery will hold a prominent place in the treatment of all but well localized periampullary tumors, if surgical risk and the anticipated chance of cure are carefully considered in each case. The few five-year survivals reported after resection for primary carcinoma of the pancreas do not

ify extending the indications for resection in these cases. Re-ion in well localized tumors arising outside the pancreas is er justified by a lower mortality and higher survival rate. ermination of the origin of tumor at the time of operation herefore important. Palliative procedures will be necessary poor-risk patients and when the tumor involves adjacent l structures. The easiest enterobiliary anastomosis that will eve jaundice after the diagnosis is proved by biopsy is the cedure of choice. Radical pancreatoduodenal resection as trictly palliative procedure has been used primarily for v-growing tumors; and it is doubtful that a longer survival ılts or has offset the increased mortality.

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Palliative surgery will hold a prominent place in the treatment of all but well localized periampullary tumors, if surgical risk and the anticipated chance of cure are carefully considered in each case. The few five-year survivals reported after resection for primary carcinoma of the pancreas do not

Detection of Common Duct Stones

Introduction

There is no present-day controversy about the desirability of removing all stones in the biliary duct system at the time of definitive operation. The differences are concerned only with the preferred methods of determining whether such stones are present and how to get them out. One of the classical indications that there is a stone, namely dilatation of the common bile duct and common hepatic duct, has been shown to be unreliable since dynamic resistance to flow can result in dilatation in the absence of stones.

There has been a curious history of differences of opinion regarding common duct stones throughout the era of aseptic surgery. It was known in the late 1800's that multiple large stones in the hepatic ducts or in hugely dilated extrahepatic ducts may cause "little inconvenience" whereas a "small gall stone in the ampulla is accompanied by far more disturbance than a multitude of calculi scattered through the intrahepatic ducts" (Bland-Sutton). The gravity of the disease was judged at that time almost entirely by the completeness and persistence of jaundice, which, if unrelenting, would surely cause death from hemorrhage. As a result among the prevailing contentions were: Common duct stones should not be removed until the extrahepatic bile ducts become dilated sufficiently to admit the ungloved finger; the stones should be crushed within the duct with instruments and allowed to pass into the duodenum. We have progressed since that time.

The two methods found useful and described here have in common thoroughness and painstaking persistent effort.

J. H. M.

Operative Cholangiography

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Controversy still exists among surgeons as to the value of operative cholangiography either in the primary detection of stones before choledochotomy or as insurance against overlooked or residual stones after choledochotomy. Some surgeons now consider it essential to good biliary tract surgery. Unfortunately, those opposed to the frequent use of this procedure have either had limited experience with its use or have not adhered to a strict method which would render good quality roentgenograms.

Prerequisites for Success

Too often those professing knowledge of operative cholangiography have discarded the procedure following several unhappy experiences due to an unstudied technique and films too poor for accurate interpretation. While from our early difficulties with the method we can understand this attitude, nevertheless, we cannot believe that accomplished surgeons will be satisfied indefinitely without the facility of operative cholangiography. For the major part of the first two years in which we were developing a dependable technique, we were often more confused than aided by the method; there were delays, and poor quality films. Technical errors led to false positive as well as false negative interpretations. Many of these frustrations can now be circumvented by those wishing to have operative cholangiography, by studying an established method. However, it is only by repeated use and recurring familiarity with a coordinated technique that it can become satisfactorily dependable. Then, but only then, will the operating time, when

attains more technical value in cholecystectomy for *acute* cholecystitis. Here the structures about the common duct may be "frozen"—yet coincident stones are known to occur in the common duct in about equal frequency in acute disease. Especially in such an instance an unnecessary common duct exploration may add considerably to the morbidity.

4. To discover the course of the common duct and insure its integrity in certain technically difficult cholecystectomies and in certain secondary operations on the biliary tract. It has proved helpful in several instances of cancer of the extrahepatic duct in determining the feasibility of palliative decompression.

5. To outline possible congenital abnormalities and deviations from the normal in the arrangement of the biliary radicles. Although the latter is a less frequent application, on occasion it assumes a crucial role in the choice of the surgical procedure.

Technique

The technique of operative cholangiography as performed in our surgeries is not complicated.* An easily portable Bucky diaphragm is placed on the operating table in a position which will cover the patient's abdomen from diaphragm to pelvic brim. This grid is utilized in all cases *scheduled* for cholecystectomy whether or not the surgeon anticipates operative cholangiography. Several of these grids are therefore required for a busy hospital. They are not expensive. Cushions are placed at either end of the grid tunnel to compensate for its height. The x-ray technician supervises the placing of the patient on the operating table, noting that the biliary tract is centered properly over the x-ray casette. The patient is placed supine, there being no need in our experience to rotate the spine in one direction or another.

To confirm the proper centering of the area to be visualized, a control film is taken prior to draping the patient. This is immediately developed, and any necessary change in position of the patient is accomplished prior to the appearance of the surgeon. An experienced technician requires no checking

* A sound track, color film by the senior authors portraying this technique is available through either the American College of Surgeons' Film Library, Chicago, Illinois, or the Film Library of the American Cyanamide Company, Danbury, Connecticut.

considering large series of cholecystectomies, be actually reduced, and the morbidity from unnecessary common duct explorations be cut to a minimum.

The present authors cannot accept the philosophy that surgical intuition is more accurate than x-ray visualization. At the same time, it is admitted that no laboratory test is a substitute for judgment, although dependable tests properly interpreted constitute a part of judgment. A resident recently commented that the ten minutes spent in x-raying the duct was more convincing than the longer time often spent in debating whether or not the duct was to be opened.

It should be unnecessary to emphasize that an interested and cooperative Department of Radiology is a prerequisite for successful operative cholangiography. Each procedure during the initial experience should be supervised by a radiologist who has at least become familiar with the minimum equipment necessary and the rules governing the production of good quality radiograms by portable equipment.

The surgeon should gain familiarity with proven techniques as a background for devising his own method. Otherwise, he and the radiologist are apt to wallow through the morass of error and disappointment so frequently discouraging to the occasional user.

Applications and Rationale

Without need for elaboration, we consider the following as the most important uses of operative cholangiography.

1. As a cardinal step after removal of stone or stones by open choledochotomy, to reliably demonstrate the presence or absence of residual stones—and hence to obviate a second operation.

2. To determine at the time of cholecystectomy, in the absence of positive indications such as obstructive jaundice, whether or not choledochotomy is required. Unsuspected common duct stones will be discovered through operative cholangiography. At the same time the procedure may obviate the unfruitful exploration for such borderline indications as small stones in the gallbladder or questionable dilatation of the common duct.

3. The use of operative cholangiography listed under (2)

than clipped. Prior to removal of the gallbladder a polyethylene catheter is threaded through the cystic duct into the common duct and held in place by two ligatures tied about the cystic duct and its contained polyethylene tubing (Fig. 1). It should be emphasized that the polyethylene tube should not be inserted beyond the common duct into the duodenum and the opaque medium filling the transparent tubing must be free of air bubbles before the tube is inserted into the cystic duct. Four to 7 cc. of either 50 per cent Hypaque or 35 per cent Diodrast is then injected slowly and without force by syringe through the polyethylene tube.

At the completion of the injection, after the anesthetist has signaled complete control of respiration to the x-ray technician, an exposure is taken. An immediate second film is taken following the injection of another 3 to 4 cc. of contrast material. This second film is indeed important, in many instances either confirming the presence or absence of abnormality suspected on the original film. The taking of two films usually obviates repeating the procedure. If desired, it is possible to take these films in stereoscopic projection by shifting the radiographic tube between exposures. The x-ray machine is removed from the room. The two films are quickly developed in an adjacent dark room with fresh solutions heated to at least 75° C. to accomplish more rapid development. The total clapsed time from the moment of injection to developing and viewing the films is ordinarily five minutes. During this time the surgeon may complete the cholecystectomy.

Objections Answered

Critics of the procedure of operative cholangiography have pointed out not only errors of omission, but errors of commission. The argument as to errors of commission is not a truly valid one in that a considerable percentage of the same common ducts would have been explored on the basis of criteria for exploration established by these critics. Errors of omission are rare and are usually found in those instances in which stones have been removed from the common duct and cholangiography is being done to check for residual stones. In this instance, stones may be mistaken for air bubbles and their import discounted. Errors become insignificant once the surgeon has established a meticulous technique and the radiologist has be-



Fig. 1. Our method of operative cholangiography depends upon the insertion of a polyethylene catheter into the cystic duct and thence into the common duct. The cystic duct is ligated and then cut halfway across, the polyethylene catheter (free of air bubbles) is then inserted and anchored by a second ligature. On occasion a beveled end may pass where the square end fails (From Baker, J. W and Lawrence, G. H.: Preoperative and Operative Decisions in Gallbladder and Bile Duct Surgery. S. Clin. North America, October, 1958.)

by a radiologist on this aspect of the procedure. In our department, high speed screens are employed. We do not utilize high speed films, since their development time is longer and some detail is lost, especially if used in conjunction with fast screens. Radiographic equipment consists of a 100 milliampere rotating anode tube on a portable generator with a KVP rating of 85. All radiographic exposures are done at a maximum time of 0.3 seconds at a distance of 30 to 36 inches, employing on the average 75 KV. A radiographic cylinder is always in place, both for the protection of surrounding personnel and for production of superior quality radiographs. In especially heavy patients, KVP is increased to a maximum and the tube-film distance reduced if necessary. There is no compromise in the exposure time factor.

The surgeon must plan his operation so that no radiopaque materials, such as towel clips, marks, sponges, or gastrointestinal tube, will interfere with x-ray interpretation. In furthering this purpose, towels are sutured to the wound rather

The increased morbidity of choledochotomy has been cited in the literature. Frequently, the uncertain decision not to explore the duct has been reinforced by the demonstration of a normal biliary tract by operative cholangiography.

The argument that the procedure adds increased cost to the patient is countered by the usually decreased total elapsed hospital time in cases in which common duct exploration has been found unnecessary.

Results

As operative cholangiography has proved both rewarding and reliable, we now use it on approximately 90 per cent of



Fig. 3. Operative cholangiogram during cholecystectomy for *acute* cholecystitis demonstrating multiple nonopaque stones in a common duct slightly larger than normal without obstruction at the ampulla. A follow-up operative cholangiogram after removal of stones demonstrated the intrahepatic ducts to be normal.

come familiar with the normal variations that appear in cholangiography.

There is no increased expense in regard to special equipment since every hospital should have a minimum of the equipment described.

The radiation exposure, both to the surgeon, his assistants and anesthesiologist, has proved consistently to be always well below accepted tolerance limits. Radiation exposure to the patients in the age group under consideration is of no concern.

Prolonged operating time has been held as a disadvantage by some. Actually, the procedure has reduced the uncertainty of decision and as a result the operating time has actually not been increased.

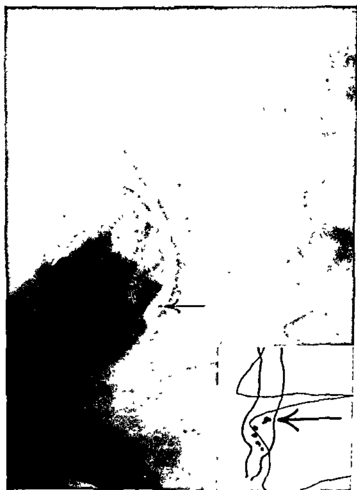


Fig. 2. Operative cholangiogram demonstrating unsuspected stones in a common duct of normal size The inset demonstrates the stones in more detail. There was no history of jaundice, and the serum alkaline phosphatase was normal (From Baker, J W. and Lawrence, G. H.: S. Clin North America, October, 1958.)

ing entrance of opaque material into the pancreatic duct have been unfounded. While the patient may experience a transient rise in the serum amylase following operative cholangiography, this has not proved clinically significant.

Summary

Following our experience in the past four years with operative cholangiography, we now consider it an essential and integral part of the surgical approach to disease of the extrahepatic biliary system. Its advantages far outweigh its disadvantages. The combined interest and cooperation of the surgeon and the radiologist are essential to the success of the technique.

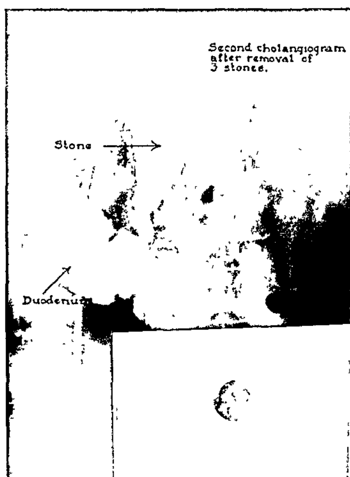


Fig. 4. Large dilated common duct in which even large stones may be elusive. Operative cholangiogram through the T-tube after removal of three stones shows a residual solitary stone missed by the surgeon

our patients undergoing biliary tract surgery. We have found it especially useful in proving patency of the common duct and the absence of retained stones following choledochotomy for cholelithiasis (Figs. 2, 3 and 4). We have also relied on the operative cholangiogram in making a decision for or against choledochotomy at the time of cholecystectomy for cholelithiasis in all but the obvious cases. A review of our experience over the past one and one-half years revealed three false positive interpretations, but more important, revealed four unsuspected positive cholangiograms. In these choledochotomy might have been neglected for the duct was of normal size and there was none of the customary indications for common duct exploration. We have experienced no increased morbidity following the performance of operative cholangiography. Our early worries concerning the occurrence of pancreatitis follow-

Operative Findings

At operation certain findings definitely indicate, and certain other findings suggest, the advisability of exploring the common duct. In general, when in doubt, the surgeon should explore the duct.

The operative findings discussed below serve as indications for exploration of the common duct.

If palpation of the extrahepatic biliary ducts definitely reveals, or at least makes one suspect, that a stone is present, the duct should be explored. Failure to palpate a stone is not conclusive evidence that no stone is present.

Regarding dilatation of the common duct, most authors would subscribe to this statement: the common duct may or may not be dilated when the gallbladder is removed or the cystic duct is occluded; it is always dilated when the lower end of the common duct is occluded by neoplasm; and it is usually dilated when common duct stones are present.

Just what constitutes dilatation of the common duct, or what is the diameter of the normal common duct? Vibert and I[7] measured the diameter of the common duct in 112 patients operated on for disease of the biliary tract. We found that the diameter in 98 patients without stones or obstruction ranged from 4 to 17 mm. (average 8.85 mm.). In 11 patients who had common duct stones the diameter ranged from 7 to 17 mm., the average being 10.90 mm., or approximately 2 mm. larger than the average in patients without stones or obstruction. The other three patients had obstruction due to neoplasm. Some bile ducts that did not contain stones were as large as any that did contain them. Even more significant, eight of the 11 common ducts that contained stones were not large but were between 7 and 11 mm. in diameter. It is therefore obvious that diameter alone is not a reliable sign as to whether the common duct contains stones.

Thickening of the wall of the common duct usually indicates a chronic, inflammatory process and is commonly caused by stones within the duct.

If numerous small stones are present in the gallbladder, and especially if one is found in the cystic duct, stones may be present in the common duct. Enlargement of the cystic duct

The Detection of Stones in the Common Bile Duct: Operative Exploration

Deward O. Ferris
*Mayo Clinic and Mayo Foundation**

One of the first decisions the surgeon must make in cholecystectomy for cholelithiasis is whether to explore the common duct. Obviously, a common duct stone that is overlooked during cholecystectomy may necessitate a subsequent operation. On the other hand, the operative mortality rate for cholecystectomy alone varies from 0.5 to 2.0 per cent, whereas it is 2 to 4 per cent after both cholecystectomy and operative exploration of the common duct. This increase in rate is noted particularly in the older age group. The advisability of exploring the common duct must be carefully considered in every operation for cholelithiasis. Certain information obtained during examination of the patient and certain findings encountered at operation help the surgeon determine whether to explore the bile ducts.

It is well known that most patients with stone in the common bile duct experience a severe, colicky type of pain in the upper part of the abdomen on one or more occasions, and that most have jaundice, although some have neither.[10] Also, chills and fever frequently are associated with choledocholithiasis. Obviously, then, certain symptoms should cause the surgeon to suspect the possibility of choledocholithiasis and help him form a preoperative opinion about whether to explore the common duct. Equally true, the absence of these symptoms should not be interpreted as definite evidence that there are no stones in the common duct.

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the common duct. If the scoop is gently directed against the posterior wall of the duct it is less likely to push the stone ahead of it. Likewise, the angle of insertion into the duct is important since, if the shaft of the scoop is bent too much, the end of the scoop will impinge on the anterior wall and tend to push stones ahead of it. Palpation of the site while the scoop is within the duct often helps locate stones and also helps determine the relationship of a nodule to the duct.

USE OF DILATORS BEFORE CLOSING COMMON DUCT TO DEMONSTRATE LACK OF OBSTRUCTION. It has become an accepted principle in surgery of the biliary tract that the surgeon must demonstrate lack of obstruction of the distal end of the common duct before he closes it after choledochostomy. Easy passage of a 3 mm. dilator demonstrates this. However, all surgeons in this field have at times experienced extreme difficulty in passing a probe dilator or scoop through the sphincter of Oddi even when

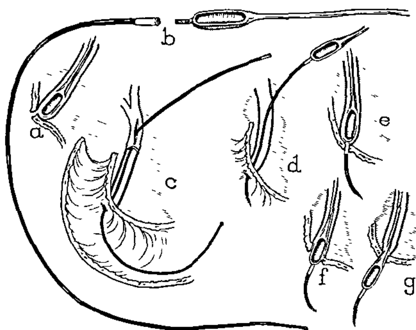


Fig. 1. In *a* the ordinary scoop is in such a position that a false passage might easily be made. In *b* the most commonly used new scoop, which is 6 mm in diameter, is shown with its threaded projection and the detachable 12 inch filiform. This length of filiform is just enough so that (*c*) once the tip has been successfully introduced through the sphincter of Oddi into the duodenum it need not be withdrawn during change of scoops or dilators. In *d, e, f,* and *g* is illustrated how accurately and safely the scoop can be introduced and removed. (Reproduced from Ferris, D. O: A New Common-Duct Scoop. Proc. Staff Meet., Mayo Clin 33:117–118 [Mar. 5] 1958.)

suggests that a stone has passed through it and that exploration of the common duct is therefore advisable.

The surgeon must always be mindful of the significance of Courvoisier's law. Jaundice and obstruction of the common duct induced by carcinoma of the head of the pancreas are associated with a dilated gallbladder, whereas jaundice produced by stone in the common duct is associated with a small, shrunken and usually fibrotic gallbladder.

If bile obtained on aspiration of the common duct contains sediment, sand or any abnormal constituent, exploration is indicated.

In a recent three-year period at the Mayo Clinic the common duct was explored in 24.5 per cent of all cholecystectomies for cholelithiasis. Stones were found in approximately one-half of the common ducts explored, that is, in 11.1 per cent of the cholecystectomies.

General Considerations in Surgical Management

If the common duct is explored in the search for a stone the surgeon should not be satisfied until he has made every effort to find one. Likewise, painstaking effort should be made to remove every stone found.

The common bile duct has earned universal respect. Injuries to it are indeed serious. The surgeon teaching in this field finds just cause for using the words "gently" and "accurately" many times a day.

In my experience the biliary passage cannot be explored satisfactorily through the stump of the cystic duct. A longitudinal incision 1 to 2 cm. in length in the upper part of the common duct is preferable.

Technique of Stone Removal

Usually, the stone or stones are readily located or removed with the ordinary bile duct scoop. The choice of a scoop and its manipulation are much more important than most surgeons assume. The scoop should be considerably smaller than the diameter of the duct and its shaft may be bent at a specific angle. *It is easy by careless manipulation to push the stone ahead into the hepatic radicles or into the pancreatic portion of*

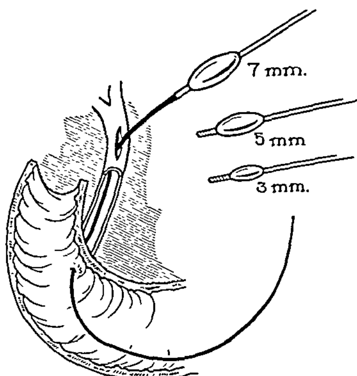


Fig. 2. The detachable 12 inch filiform has been introduced through the sphincter of Oddi and is attached to the 7 mm. dilator. The threaded projection for attachment of this filiform can be seen on the 5 mm. and 3 mm. dilators. (Reproduced from Ferris, D. O.: A New Dilator of the Common Bile Duct. Proc. Staff Meet., Mayo Clin. *33*:344–346 [June 25] 1958.)

the common duct and sphincter of Oddi without risk of making a false passage and with minimal trauma.

Fibrosis of the sphincter, if demonstrated, requires correction by transduodenal sphincterotomy.

If, in any case, the surgeon is not entirely satisfied that the sphincter of Oddi and the ampulla of Vater are normal, it is best to open the duodenum and explore from this approach as well.

Irrigation of the Ducts

Another helpful procedure is irrigation of the ducts with physiologic saline solution. For this purpose a metal syringe that holds 3 or 4 ounces and has a long, malleable metal tip has been most useful. The flushing out of remaining calculi is dependent upon a strong return flow of fluid and such a flow may be obtained better with this syringe than by other meth-

this structure has been normal. The common duct is easily damaged and extreme care and gentleness are required in instrumental exploration of it. In these difficult cases the surgeon has these alternatives: he may desist short of complete exploration, or he may exert a little more pressure and possibly make a false passage with accompanying leakage and damage to adjacent structures. A filiform-guided scoop (Fig. 1) has been a great help to me in the safe and satisfactory exploration of the common duct and in engaging and removing impacted stones in this region.[5]

Instrumental Exploration and Evaluation in Partial Obstruction of the Sphincter of Oddi

More and more attention has been given in recent years to partial obstruction of the sphincter of Oddi by spasm, fibrosis, and scarring.[1, 3, 4, 8, 9] Several points should be kept in mind in the instrumental exploration and evaluation of this condition

First, graduated dilators, such as Bakes', may be used to calibrate the diameter of the sphincter. In successively passing dilators with diameters of 3 mm., 4 mm., 5 mm., and so forth, one soon arrives at a size that will not pass with ease. The largest size that passes with ease is the caliber of the duct at the sphincter. This normally is in the range of 3 to 7 mm.

Second, the dilators are of course used to dilate the sphincter of Oddi. Dilatation of this sphincter, like dilatation of other sphincters, is only temporary. Extreme dilatation may cause temporary lack of function of the sphincter, but it also may cause tearing and splitting of the structures with the possibility that excessive scar tissue may be laid down; then, when this contracts, it causes a degree of stenosis. Branch and coworkers,[2] in their investigation of the consequences of instrumental dilatation of the sphincter of Oddi in dogs, showed that scarring actually does occur after extensive dilatation and that dilatation gives no permanent enlargement; they concluded that no further dilatation should be carried out after patency has been ascertained. I have made it a practice not to pass a dilator of a diameter greater than 7 mm.

The third point regarding dilatation is to avoid creation of false passages The use of a filiform-guided dilator[6] (Fig. 2) makes possible more accurate evaluation of the distal part of

through which bile may drain to the skin surface, should leakage occur from the opening in the common duct from which the tube has been withdrawn.

Summary

No single finding or maneuver detects common duct stones infallibly. The surgeon must carefully evaluate every aspect and utilize every means available in order to approach 100 per cent success in an operation. "Gently" and "accurately" are bywords in all explorations of the biliary tract, and when applied they pay great dividends.

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ods usually employed. The long, malleable tip permits delivery of the irrigating solution to any desired area within the ducts.

Operative Cholangiography

Operative cholangiography affords another means of detecting common duct stones. In general, I use it "in addition to" rather than "instead of" other means of evaluation. As in most procedures, certain risks are associated with it; the real danger is injection of radiopaque medium into the common duct under so much pressure that it enters the pancreatic duct and ruptures some pancreatic acini, causing acute pancreatitis. However, this danger may be avoided if injection is made at a pressure of 20 cm. of water or less. The chief technical difficulty is the elimination of misleading shadows due to air bubbles. These are easily eliminated by flushing the common duct with isotonic saline solution from a closed system (intravenous bottle and tubing), with the patient in a Trendelenburg position; the duct is gently manipulated and the air bubbles float up into the duodenum. The time to have the information that the cholangiogram provides is during the operation, not some days later, and this information I arrange to have at this time in every case.

Proper Time for Removal of the T-Tube

When should the T-tube be removed? I feel that the tendency has been to leave such a tube in place too long. Any foreign material used in the form of a tube in the common duct causes precipitation of calcareous material around the tube if left in place long enough. Ordinarily, I leave the T-tube in place no longer than two weeks. Some have said that a tube should be left in place until the bile duct has returned to normal size. Actually, a return to normal size may take months, or may never occur. As long as all stones and other forms of obstruction have been removed, continued presence of the tube would seem unnecessary. Generally, a T-tube should not be removed prior to nine or ten days after insertion. This much time is required for the edema and spasm incident to instrumental exploration of the common duct to disappear. Also, this much time allows development of a fairly adequate tract

Management of the Common Duct Wound

Introduction

Halsted said in 1896, "Several well-known English surgeons state that no harm is done by leakage from the [common bile] duct, provided one drains down to the sutures. I think that one should, if possible, so suture the duct that its contents cannot escape."

He wrote later in 1898 decrying the disposition of surgeons of that day "to wait weeks or months or even years for the [common bile] duct to dilate and thicken rather than interfere promptly in cases of obstruction of the common bile duct by stone." This course was followed because of the belief that only a thick-walled dilated duct could be sutured securely. He said, "I know from operations on dogs and man that the normal bile ducts can be sutured easily, accurately, almost infallibly, and without danger of leakage or obstruction."

Initial attempts to overcome inability to suture the bile duct were to omit sewing entirely, using instead a glass tube implant with gauze carefully packed around it to fill the unsutured abdominal wound. The gauze and glass tube were removed gradually when a sinus tract had formed.

The argument has continued to the present day with added evidence that intraductal pressures, tonus of the sphincter of Oddi, use of morphine, physical characteristics of bile, etc., substantiate either contention. The significant facts that complications do arise from the implantation of T-tubes and that postoperative cholangiograms are of diagnostic value are glossed over.

J. H. M.

Management of the Common Duct Wound by T-Tube Drainage

Henry Doubilet

New York University College of Medicine

Although T-tube drainage of an opened bile duct is almost universally employed in this country, there are still differences of opinion as to whether this is necessary or desirable. Some hold that primary closure of the common bile duct is feasible and preferable, while in Europe a straight catheter is used for drainage. It is appropriate to restate the arguments in favor of T-tube drainage of the common bile duct.

Precautions Prior to Insertion of a T-Tube

When exploration of the bile ducts for stones is considered necessary, operative cholangiography should be performed. Even if a stone or stones are palpable, the cholangiogram can give more exact information as to their number and site, particularly when stones are intrahepatic or at the ampulla. Following removal of presenting stones, the ducts are washed copiously through a fine catheter inserted upward and downward. For more complete exploration, especially if more than one stone is present, transduodenal sphincterotomy is performed, and the lower end of the common bile duct explored from below as well as from above. This will often reveal stones missed by probing, washing, or cholangiography.

After the ducts have been cleaned, a T-tube is inserted. It should never be larger than a No. 16 F. even if the common duct is very wide. Each transverse limb should be no longer than 1 cm. Impingement of a long upper limb against the junction of the right and left hepatic ducts may block one or the other; a long lower limb may distort and angulate the lower

4. *The tonus of sphincter of Oddi can be measured through the T-tube.* If the sphincter is hypertonic, removal of the T-tube will result in a fistula which may last days or weeks. The tonus of the sphincter can be measured by holding the tube perpendicular for at least five minutes. The level of fluid in the tube at the end of that period measured from the anterior superior spine as a base is the tone of the sphincter muscle. In a supine patient the anterior superior spine is usually at the level of the sphincter of Oddi. If the resistance of the sphincter of Oddi is more than 150 mm. of water, the tube should be tied off for 48 hours and the tonus remeasured. In most instances continuous pressure of bile secretion will relax the sphincter so that resistance drops to about 120 mm. of water.[2] If the tube is removed at this time, the fistulous tract will close immediately.

5. In the presence of acute or chronic cholangitis, *prolonged drainage can be achieved by a T-tube.* Dilatation of the sphincter of Oddi may be effective for a few days, but after a week the tonus returns to normal (about 150 mm. of water). At this time T-tube drainage is more effective in reducing biliary intraductal pressure and permitting the acute process to resolve more rapidly.

T-Tube Drainage Versus Primary Closure of the Common Bile Duct

Mirizzi, an advocate of primary closure, gave the following conditions as essential for this procedure: (1) patency of the sphincter of Oddi, (2) complete removal of stones, (3) the presence of a normal pancreas, (4) perfect suture of the incision in the common bile duct, (5) drainage of the subhepatic space.

Except for Mirizzi, advocates of primary closure of the common bile duct do not practice operative cholangiography as a routine procedure.[4] Effective operative cholangiography must visualize the whole biliary tract, not simply the entrance of radiopaque solution into the duodenum. This can be achieved only by (a) exposure of the x-ray plate while radiopaque medium in adequate amount is being injected and (b) under spasm of the sphincter of Oddi, produced by application of 0.1 NHCl to the papilla through a Rehfuss tube. This deliberately

end of the common duct and produce partial obstruction. The T-tube should be brought out at the right lateral end of a transverse abdominal incision or through a stab wound in a vertical incision, and held in place at the proper distance by means of a cuff of larger rubber tubing through which safety pins are inserted.[5] Adhesive straps attached to the safety pins will not permit *shortening of the distance between the bile duct and the* abdominal wall, and thus will prevent angulation of the duct. They will also prevent accidental removal of the T-tube. Bile should be collected in a small bottle attached by its neck to the body in such a way that the fulcrum of swing of the bottle is close to the point of exit of the tube. The T-tube itself should not be attached to the bottle by adhesive since accidental traction on the bottle might then pull it out. If a soft rubber cap is placed on the bottle and the T-tube tightly fitted into it, a second opening should be made in the rubber cap to permit exit of air. Without this precaution a complete tubal obstruction can occur, with leakage of bile into the peritoneal cavity. Bile drainage into a bottle placed on the floor under the bed should never be used, since traction resulting from the weight of a long connecting tube might pull out the T-tube.

Value of T-Tube Drainage

1. *Bile will flow through the T-tube instead of seeping into the peritoneal cavity.* If the tube is brought out laterally, the hydrostatic pressure resistance will be less than the normal resistance of the sphincter of Oddi, and most of the bile will flow into the bottle for the first few days.

2. In the presence of obstruction by a residual stone or by postoperative acute pancreatitis, *the tube acts as a safety valve,* preventing passage of bile into the peritoneal cavity.

3. *Postoperative cholangiographic studies can be made on the seventh day to check for residual stone.* The absence of symptoms and signs postoperatively does not exclude the possibility of such a stone. It can remain asymptomatic many years, but intermittent increased resistance to flow of bile may produce biliary cirrhosis. Abundant evidence to support this concept can be found in patients who have had no history of jaundice, but who, at a primary operation, are found to have common duct stones associated with biliary cirrhosis.

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produced spasm of the sphincter increases back pressure and fills the whole biliary tract.

Although Allen and Wallace,[5] as well as Welch,[6] are quoted by Herrington on the value of ampullary dilatation in permitting passage of residual stones, his own results show that of 153 cases of primary closure plus ampullary dilatation with a No. 7 or 8 Bakes dilator, in at least five, and possibly eight cases, residual stones were found. Although this record is excellent, Mirizzi's second condition for primary choledochal closure is not fulfilled. In the presence of a residual stone, it is certain that T-tube drainage is preferable to primary closure.

Passage of a sound through the sphincter of Oddi into the duodenum may produce severe trauma or be impossible due to the fact that the ampulla occasionally lies at right angles to the long axis of the common duct. In such cases, the sound may rupture the ampullary wall and create a false passage. Such a passage will heal readily and leave a spastic sphincter intact. Herrington has pointed out that, when passage of a sound is difficult, the duodenum should be opened and the sound passed under vision. Under such circumstances would not surgical principles be served better by cutting the sphincter cleanly rather than by distending the ampulla? Sphincterotomy results in a permanent destruction of the sphincter of Oddi rather than the temporary paralysis which is achieved by a large sound.

It is technically possible to close the common duct in water-tight fashion, just as it is technically possible to close the high-pressure aorta. The difference is, however, that blood clots and seals small openings. Bile, on the other hand, not only does not clot, but flows more freely than water because of its surface action capillarity. Thus, the closure must be more secure than "water-tight." This is difficult to achieve, even in large ducts.

The last essential condition stated by Mirizzi which permits primary closure of the common duct, is drainage of the subhepatic space. This is necessary since complete removal of all choledochal stones is never achieved in practice. However, a drain is not needed when a T-tube is inserted into the common bile duct.

A T-tube does not injure the common bile duct if properly prepared and fastened in place correctly at the surface of the abdomen. The common bile duct is not a contractile organ,

as claimed by Mirizzi, but an elastic, distensible structure which is not affected by a small inlying T-tube. There are many cases on record of prolonged T-tube drainage, sometimes over a period of years, without evidence of injury to the duct.

Conclusions

Properly performed T-tube drainage of the common bile duct prevents passage of bile into the peritoneal cavity, even in the presence of a residual stone or of postoperative pancreatitis, and also permits cholangiographic studies before removal of the tube. In addition, the presence of a hypertonic sphincter can be detected and proper steps taken to avoid prolonged drainage from a biliary fistula after the tube is removed. Primary closure can never be completely safe, since removal of all common duct stones at operation cannot be achieved, nor can postoperative pancreatitis always be prevented.

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Primary Closure of the Common Bile Duct

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T-tube drainage of the common bile duct following duct exploration for calculus disease has been a widely accepted principle, and its employment as a routine procedure has been unchallenged over the years by most surgeons. On the other hand, those surgeons who have practiced primary closure of the common duct wound have found this method to be most satisfactory in the routine case subjected to choledochal exploration. Herein is recorded an experience encompassing a recent twelve-year period, during which time a group of patients underwent exploration of the common bile duct followed by primary duct closure.

Historical Aspects

Closure of the common duct (primary choledochorrhaphy) by no means represents a new surgical method. The procedure was apparently first used by the German and French surgeons shortly after the beginning of the twentieth century.[3, 4, 5, 12] Von Eiselsberg did much to popularize the method and stressed the importance of thoroughly dilating the papilla of Vater when contemplating primary choledochorrhaphy. In addition, he passed a small drain through the ampulla of Vater later to be expelled by rectum. Richter,[10, 11] in this country, was a confirmed advocate of the principle and published several articles on the subject. No doubt, he was perhaps a bit audacious in his operative approach in that he omitted entirely drainage of the right upper abdominal quadrant in his cases. This led others, who followed his teachings, to suffer the bitter experience of encountering cases of bile peritonitis during the postoperative

period. Thus, as a result, the procedure of primary common duct closure lost some of its earlier popularity.

William Halsted[7] was intrigued by the principle of ductal closure and cited the disadvantages accompanying the routine employment of T-tube drainage. During his later years, he closed the common duct primarily and established drainage by passing a small rubber tube into the stump of the cystic duct. This procedure is still taught by many of his former residents. Primary choledochorrhaphy has been practiced for some time by most of the South American surgeons, mainly through the influence of the writings of Mirizzi[9] of Argentina. American surgeons, however, have generally been reluctant to adopt the operation, but in some centers today the procedure is being used with increasing frequency.

Reasons for Advocating Primary Closure of the Common Duct

In observing patients subjected to duct exploration with T-tube drainage, we noted that many of them were undergoing lengthy hospitalization with associated economic strain, and that increasing demands were being placed on the nursing personnel during the postoperative period. The morbidity among these patients was of particular concern when compared with that following cholecystectomy in which the common duct was not explored. One was always reluctant to consider removal of the T-tube before the tenth or twelfth postoperative day and the bile drainage which followed removal of the T-tube was a source of annoyance usually for several days. Being familiar with the procedure of primary ductal closure, we had the thought that perhaps the postoperative hospital stay, as well as the morbidity, might conceivably be lessened by performing primary closure of the duct in certain instances. It seemed logical to assume that T-tube drainage is less desirable than a method which would immediately restore normal bile flow into the intestinal tract through the natural common duct channel. This can be accomplished by primary closure of the common duct wound after establishing the complete patency of the ampulla of Vater, which will be emphasized later. In our experience, if such an approach to the problem is carried out, the incidence of overlooked stones in the common duct will be very small indeed. In the event the surgeon should leave a com-

mon duct stone behind, re-exploration is usually necessary and it is difficult to conceive how the presence of a T-tube in the common duct in such a circumstance can eliminate the surgeon's problem.

The procedure of closing the common duct wound was given a preliminary trial and was carried out by us in a small group of 41 patients.[6] We were impressed by the smooth postoperative course experienced by this group.

Clinical Experience with Common Duct Closure

As a result of the preliminary study, other surgeons at the Vanderbilt University Hospital began the employment of primary ductal closure and likewise obtained gratifying results.

Results Compared with Those of T-Tube Drainage

After a reasonable experience with the procedure had accumulated, a study was undertaken in which a group of patients undergoing choledochal exploration with primary duct closure were compared with a similar group in which the common duct following its exploration was drained using a T-tube or rubber catheter. The comparison appeared to be significant in that each group represented a comparable age range, and the pathologic process found in the common duct at the time of operation was equally severe in both groups. *It should be emphasized that the cases undergoing ductal closure did not represent a selected group.* It was found that the patients in whom the ducts were closed primarily left the hospital an average of five days earlier than the patients undergoing T-tube drainage. In the former group, the postoperative temperature elevation was less pronounced and prolonged as compared with the latter group. After excluding the usual minor postoperative complications, it was suggested that the T-tube could well account, in part, for the increased morbidity experienced by that group of patients. Likewise, in the group undergoing T-tube drainage, the major postoperative complications were indeed greater. Follow-up studies revealed that additional biliary surgery proved necessary in 5.3 per cent of 151 patients in whom the common duct was closed primarily at the original operation; whereas, further biliary surgery was necessary in

TABLE 1. PATIENTS UNDERGOING COMMON DUCT CLOSURE

No.	*Stones Present*	*Stones Absent*	*Mortality*
204	106 (50 2%)	98 (49 8%)	3.9%

13 per cent of 88 patients undergoing T-tube drainage of the duct. This surgery consisted in the removal of additional common duct stones, or exploration for suspected calculus disease or benign stricture.[8]

Clinical experience ending December 1957 revealed that 204 patients had undergone choledochal exploration for suspected calculus disease, followed by closure of the common duct wound. Of this number, 106 (50.2 per cent) were found to have calculi present in the common duct. There was a total of eight hospital deaths among the 204 patients (3.9 per cent mortality). The majority of the deaths occurred in the elderly age group of poor-risk patients with advanced cardiovascular disease (Table 1). One death was related directly to the operative procedure. This occurred in a 41-year-old man who underwent a very difficult duct exploration and, as the result of an operative error, suffered a small accidental tear in the posterior wall of the suprapancreatic portion of the common duct during instrumental dilatation of the ampulla. The patient expired 24 hours later of peripheral vascular collapse. At necropsy, a large collection of bile was present in the right upper quadrant of the abdomen, with an associated fibrinous peritonitis. The closed common duct wound was intact. Leakage from the site of the perforation was no doubt responsible for his demise.

The Importance and Methods of Establishing the Complete Patency of the Ampulla of Vater Before Closure

If one elects to close the choledochotomy wound, a primary requisite is to first establish complete patency of the ampulla of Vater. This can usually be accomplished by a thorough and meticulous supraduodenal exploration of the common duct, transduodenal exploration with direct inspection of the ampulla when deemed advisable, and in certain instances by operative cholangiography.

In our experience, one of the important steps in perform-

ing common duct exploration is adequate dilatation of the ampulla of Vater following stone removal. The ampulla is usually rendered patulous with graduated dilators up to a 6 to 7 mm. size. This insures adequate drainage of bile into the duodenum and makes for a smoother postoperative course. This is further evidenced by the negligible amount of postoperative bile drainage via the stab wound drains placed in the right upper quadrant. Allen[1] feels strongly that dilatation of the papillary muscle is effective in discharging any small residual common duct stones and that such a maneuver does *not* cause temporary swelling in the region of the ampulla which might predispose to an intraductal pressure build-up with disruption of the choledochotomy wound. He[2] likewise showed that, without ampullary dilatations, secondary operations were necessary for the removal of overlooked stones in 4.2 per cent of his cases. In a much larger series in which the ampulla was adequately dilated, secondary operations for stone removal proved necessary in only 0.7 per cent. Welch[13] observed only one instance of retained common duct stone in a series of 50 patients undergoing ampullary dilatation. In our opinion the incidence of an overlooked common duct stone will reflect closely the thoroughness with which the duct is explored at the original operation, the adequacy of the ampullary dilatation, and the experience and judgment of the operator.

Technique of Common Duct Closure

Our preference is to create a 1 to 2 cm. vertical wound in the most accessible part of the suprapancreatic portion of the duct for the purpose of adequate exploration. A few surgeons prefer a transverse incision in the duct, while still others explore this structure through the stump of the cystic duct. The latter method seems inadequate and no doubt will result in a high incidence of overlooked calculi.

After thorough exploration of the duct, removal of intraductal calculi, and instrumental dilatation of the papilla, attention is next directed toward primary closure of the vertical wound in the duct wall. Beginning at the superior aspect of the ductal wound, a bile-tight closure is accomplished using a continuous suture of fine chromic catgut. The stitches are placed close together and the suture is tied at the inferior

margin of the duct wound. Extreme care is taken to make certain that the suture does not perforate the entire thickness of the ductal wall; only the adventitia and outer coats of the duct are included. This type of nonperforating closure further protects against bile leakage. A suture that does not penetrate the mucosa of the duct can readily be accomplished in a duct of normal thickness. We prefer to utilize 0000 chromic catgut with a small swedged needle when closing a duct of normal caliber and thickness. When a thickened and edematous ductal wall is encountered, a suture of 000 chromic catgut is chosen. A continuous stitch of this type, with the bites being taken close together and incorporating a small margin of the ductal wall, does not predispose to postoperative stricture formation. A continuous suture likewise in our experience insures against leakage of bile, more so than a single row of interrupted fine silk sutures similarly placed. As added protection, the single row of continuous catgut suture is reinforced with several non-

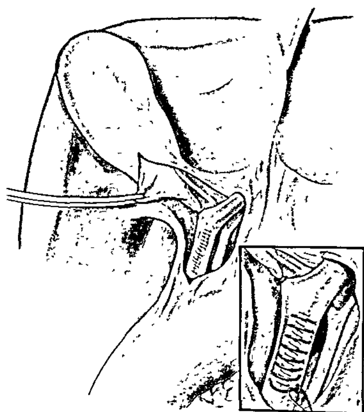


Fig 1. Demonstrating technique in primary choledochorrhaphy. (Modified from Edwards and Herrington, Annals of Surgery, Vol. 137, No. 2, February 1953. J. B. Lippincott Co.)

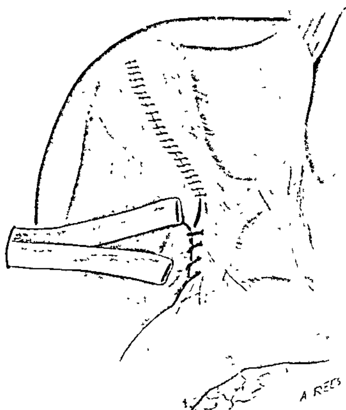


Fig. 2. Final step in technique showing the free edge of gastrohepatic omentum sutured over the common duct—gallbladder removed—drains in place. (Modified from Edwards and Herrington, Annals of Surgery, Vol. 137, No. 2, February 1953. J. B. Lippincott Co.)

perforating sutures of 5–0 silk (Figs. 1 and 2). If an accessible tab of gastrohepatic omentum is available, this structure is placed over the suture line. Two or three Penrose drains are next inserted down to the right upper quadrant of the abdomen, care being taken that the drains do not come in contact with the wall of the duct. The drains are brought to the exterior through a single stab wound and usually are left in place for five to six days.

Selected Cases in Which T-Tube Drainage of the Common Duct Is Preferred

From this discussion it should not be assumed that following choledochal exploration the common duct may be closed with impunity in every case. Quite to the contrary, there are definite conditions prevailing at operation which render T-tube drainage of the common duct a wiser and safer choice than

primary ductal closure. T-tube drainage of the duct is preferred when difficulty is anticipated in performing primary closure because the wall of the duct is indurated, edematous and surrounded by a dense inflammatory reaction. Likewise, if undue manipulative trauma is inflicted to the lower end of the common duct in removing an impacted stone, it is no doubt far safer to institute duct drainage for fear of the development of postoperative edema about the ampulla, which might conceivably predispose to disruption of a closed choledochotomy wound. If an associated pancreatitis is present at operation, practically everyone is in agreement that duct drainage is necessary. Likewise, when transduodenal sphincterotomy is performed in association with duct exploration, a T-tube should be inserted in the common duct. Following exploration of the pancreatic duct, external drainage is indeed necessary. If an inadvertent tear is created in the common duct during a difficult exploration, a T-tube is a useful adjunct to split the common duct and divert the flow of bile, thus allowing for healing of the inflicted wound. No doubt, had this procedure been performed in our fatal case, the fatality might have been prevented.

There are those who feel that a patient who presents with icterus at the time of operation should have external biliary drainage instituted following removal of intraductal calculi. In our opinion the presence of jaundice in itself is not an indication for T-tube drainage.

At present it is our firm belief that in the majority of cases the common duct might safely be closed following ductal exploration for suspected calculus disease. A thorough and meticulous exploration of the duct followed by dilatation of the ampulla renders this method both sound and feasible. If the slightest doubt exists regarding complete patency of the lower extremes of the duct, transduodenal exploration of the ampulla is next in order.

Summary

A brief historical review of the early experience utilizing primary closure of the common bile duct has been presented.

The reasons for advocating primary closure of the common duct in preference to T-tube drainage in the usual case undergoing choledochal exploration have been discussed.

A clinical experience citing the results of common duct closure as compared with T-tube drainage has shown that in the usual case the former method results in decreased post-operative morbidity and a decreased period of convalescence.

Specific indications are cited in which T-tube drainage of the common duct is preferred to primary closure of the common duct wound.

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The Repair of Common Bile Duct Stricture

Introduction

It is a sordid reflection on the surgical endeavors of this country, or any place, that there are common duct strictures to repair. Such strictures originate in practically all instances as operative errors or inadvertent injuries at the time of cholecystectomy. Much has been written concerning the prevention of such injury, and there are those who advocate, with avoidance of injury in mind, routine common bile duct exploration at cholecystectomy, and others who recommend routine operative cholangiography during cholecystectomy. Other precautions also have been advised.

Once a common bile duct stricture is present there are two general methods of correction, one involving excision of the stricture with end-to-end anastomosis of the duct. This method is ideal in principle in that the sphincter of Oddi is preserved and normal secretory relations at the duodenum are maintained. To the inexperienced surgeon this method is susceptible to re-stricturing because of excessive tension at the anastomosis, which must be avoided by proper dissection and reflection of the pancreaticoduodenal area. The second general method is the anastomosis of the common bile duct above the stricture to an isoperistaltic segment of jejunum "Roux en Y." This method also is satisfactory in that the bile is bypassed through an "artificial sphincter," thus preventing reflux of intestinal content into the biliary system. Bile, in this operation, is placed in the jejunum at a lower level than the duodenum, of course, and the complication of duodenal ulceration is possible because of separation of the acid and alkaline secretions.

As implied, both of these operative plans are quite satisfactory if the surgeon has experience with the method. However, the specter of common duct injury should never have appeared at all.

S. R. F.

Repair of Common Duct Strictures by Choledochojejunostomy

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It is established, unfortunately, that a divided common bile duct is one of the most distressing complications of operative surgery. Prompt, meticulous primary repair by end-to-end suture is the most effective corrective procedure. The general tenet that structures be restored to as near the natural state as possible applies, and in circumstances wherein the accident is recognized and dealt with at the time, results are best.

When the injury is not recognized at operation, which is frequently the case because of blind attempts to control bleeding, repair is secondary and some compromise with precise restoration to normal may be required.

Factors Leading to the Formation of Stricture

For some reason anastomosis of the cut common duct with any organ, including distal common duct, will stricture sooner or later. Our results are measured almost entirely by the time it takes for the new stricture to develop—the longer the better. This is a provoking matter. Strictures do not follow wounds in the side of the duct, no matter how carelessly managed. An opening from which a T-tube has been removed closes rapidly and with no stricture if the flow of bile by the opening is free and unresisted. Stricture must, therefore, be at least in part a feature of injury to the circumference of the duct as distinct from injury to its long axis. Another feature is the nature of fluid bile.

Circumferential suture in other tubular structures—blood vessels, for example—is not inevitably followed by stricture as

in bile ducts. Healing of wounds in arteries is aided by clotting. Fibrin fills and seals small spaces and assumes a glossy, smooth lining surface. Bile not only does not clot, but quite the reverse, leaks freely through small openings. Bile salts have a detergent surface action which promotes capillarity flow along sutures or strands of tissue. Furthermore, probably because of bile salt content, the fluid is irritating and stimulates a fibrous reaction wherever it bathes normal tissues. Bile also contains particulate matter from the size of large molecules, pigment granules, to clumps of mucus and debris which eventually obstruct the strictured duct.

Requisites of Secondary Repair

These points lead to a consideration of what is desirable in secondary repair of a strictured common duct.

First, suturing must be most meticulous. The anastomosis should be made with the objective that it will be more competent than "water-tight," because bile flows more freely and into smaller spaces than water does. There should be no analogy drawn between the healing of an arterial wall, which is aided by clotting, and the bile duct. To accomplish such a repair the tissues utilized must be healthy, mobile, and flexible. There can be no unalterable disparity in the lumen diameter of the two tubes. If proximal common duct is dilated it should be sewed to a tubular structure the size of which can be adapted to the dilated lumen. Precision in the anastomosis is impossible otherwise.

Secondly, the completed anastomosis should provide for the greatest possible unimpeded flow beyond the repaired segment. In this objective, a compromise with the desirability of restoration to the natural state is in order. In the argument for end-to-end repair at all costs, it is frequently said that the natural state is restored in that the sphincter of Oddi is again interposed for control of bile flow. So far as is known, the sphincter of Oddi functions mainly to fill the gallbladder by resisting flow and creating side-arm pressure on the passive gallbladder. This is borne out in nature in those animals such as the rat and the horse which have no gallbladders, neither do they have sphincter muscles corresponding to the human sphincter of Oddi. In practically all instances of common duct

stricture the gallbladder has been removed and a sphincter of Oddi muscle is superfluous. After repair it might even be detrimental because the resistance to flow it creates would tend to force bile into tissue spaces.

Free flow is best established by a long unimpeded tube with a large capacity to drain by siphonage. A long defunctionalized limb of jejunum with its peristaltic wave progressing distally provides such a tube.

Disadvantages created in that bile is delivered to the gastrointestinal tract at an abnormally low site are to be weighed against the more immediate and pressing circumstance of biliary obstruction by new stricture formation.

The Ultimate Choice of Method

Comparative statistical reports of results of operations for stricture of the common bile duct are mostly in terms of the time elapsing before re-stricture. These are not entirely valid because the most favorable cases, i.e., those with the least damage and in which the distal common duct is available, would have end-to-end suture. Those less favorable, because of poor conditions, would have a jejunal anastomosis.

Whenever a segment of distal common duct is found and an anastomosis of sorts can be performed, the questions should be asked: Can the anastomosis be done with healthy clear tissues of compatible size and with the care required for a better than "water-tight" closure? Will there be free flow of bile into an unimpeded distal channel? If there is any doubt about the answer to both questions being "yes," a choledochojejunostomy should be done. Thus a healthy vascularized distal tube is provided and the lumen for anastomosis can be adjusted to fit.

End-to-End Repair of Bile Duct Strictures

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A variety of procedures which are applicable for the relief of benign biliary strictures has been described. Most of these are variations of hepaticoduodenostomy as described by Mayo[6] and Walters,[7] hepaticojejunostomy as carried out by Allen[1] and Cole,[4] and end-to-end choledochocholedocostomy as developed by Lahey[5] and Cattell.[2] In some situations the condition of the structures at the porta hepatis indicates the use of one particular type of repair. Under the usual circumstances, however, our procedure of choice for the repair of biliary stricture is anastomosis of the two ends of the bile duct.

Two major factors underlie the morbidity and mortality associated with the treatment of strictures of the bile ducts: the first is the technical difficulty of most stricture repairs, and the second is the tendency for biliary anastomoses to constrict, causing subsequent recurrence of biliary obstruction. Any procedure contemplated for the repair of biliary strictures must be judged with regard to these two factors.

Evaluation of Procedures

From Standpoint of Technical Difficulty

With regard to the technical difficulty of stricture repair, we believe end-to-end anastomosis to be as feasible as hepaticoduodenostomy or hepaticojejunostomy. The main difference in these procedures as we perform them is that, with choledochocholedocostomy, the lower end of the common duct must be located and isolated. In the large majority of cases we are able to locate the lower end of the duct by using certain anatomical landmarks.[3] The most important of these is the

common duct lymph node—a large node which is always found on the inferolateral aspect of the lower end of the duct. This node is easily located after the second and third portions of the duodenum have been mobilized. The operating time consumed in finding and isolating the lower end of the duct compares favorably with the time required to construct a Roux-en-Y jejunal limb for hepaticojejunostomy or to perform an entero-enterostomy if a loop of jejunum is used.

From Standpoint of Recurrence of Biliary Stricture

The cause of the second major factor—constriction of biliary anastomoses, with subsequent recurrence of biliary stricture—is unknown. Our experience in the course of 1019 operative procedures for the relief of biliary stricture in 691 patients has led us to believe that stricture is less likely to recur after end-to-end repair. In order to compare the results of end-to-end repair and hepaticojejunostomy, we have selected from this large group 223 patients with similar strictures of the bile ducts. The following cases were omitted: those with strictures within 1 cm. of the bifurcation of the common hepatic duct, those repaired using Y-tubes or vitallium straight tubes as prostheses, and repairs other than the first carried out at the Lahey Clinic. These omissions avoid bias in case selection among the two groups. In addition, only cases from our more recent group (1948 to 1955 inclusive) were chosen. Of these 223 patients, the strictures were corrected by end-to-end anastomosis in 143 instances and by hepaticojejunostomy in 80. In the first group a satisfactory result was obtained in about 60 per cent and biliary obstruction subsequently recurred in approximately 40 per cent Of the hepaticojejunostomy group a satisfactory result was obtained in about 50 per cent. We believe that the follow-up in these cases is adequate to give a true representation of our results.[3] These results, therefore, favor the use of end-to-end repair because there is less chance of recurrent stricture at the site of anastomosis.

Additional Advantages of End-to-End Repair

Several additional advantages accrue from the use of an end-to-end repair that are not apparent in the above discus-

sion. These advantages rest mainly upon the fact that the normal anatomical relationship of the biliary tract to the duodenum is re-established. It is our impression that when hepaticojejunostomy is used as the method of repair, peptic ulceration of the duodenum is more likely to occur as a result of diversion of the alkaline bile from the duodenum. Secondly, the loss of function of the sphincter of Oddi allows regurgitation of intestinal content into the biliary tree. This factor is probably not of major importance in most cases, but we have seen patients in whom symptoms of cholangitis were not associated with biliary obstruction as proved by exploration. A sidetracking procedure in these cases proved to be of value. Finally, the use of the lower end of the bile duct usually allows the use of a T-tube to splint the anastomosis, the vertical limb emerging through the duct wall below the anastomosis. At times the upper end of the duct used in hepaticojejunostomy is too short for this purpose. We believe that an inlying T-tube brought out through the intact duct and not through the jejunum is the most favorable type of prosthesis.

Our experience with hepaticoduodenostomy as a means of stricture repair has not been great enough for us to draw accurate conclusions regarding this type of procedure. However, it is obvious that the use of hepaticoduodenostomy does not allow a functioning sphincter of Oddi to remain in the biliary tract.

Contraindications to End-to-End Repair

In some instances we do not advise the use of end-to-end repair. These situations include patients in whom the distal end of the bile duct cannot be dilated to match the diameter of the proximal end, those in whom the total length of ductal destruction has been very extensive, and occasionally those patients in whom the proximal end of the duct is of poor quality for suture. Moreover, if choledochocholedocostomy has been used for repair of stricture and has been unsatisfactory, we are reluctant to use this same type of repair again. Under these circumstances we usually advise the performance of hepaticojejunostomy.

Summary

If the local anatomical situation warrants the procedure, it is our feeling that the procedure of choice for the repair of bile duct stricture is end-to-end anastomosis. In the majority of cases we have not experienced difficulty in locating and isolating the lower end of the common bile duct for this purpose.

In our selected group of 223 cases of bile duct strictures, the results following the use of end-to-end repair are more satisfactory than after hepaticojejunostomy. We feel that it is advantageous for the alkaline biliary secretions to be delivered to the duodenum to protect against peptic ulceration. We also feel that it is important to have a functioning sphincter of Oddi between the biliary tract and the intestinal tract.

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Management of the Normal Gallbladder at Sphincterotomy

Introduction

Section of the sphincter of Oddi when dysfunction of that muscle creates disability was first proposed by Archibald in the 1920's. He had observed that those patients from whom he had removed stones lodged in the ampulla of Vater were less subject to postoperative difficulties than others who had operations on the biliary tract. He attributed these improved results to the fact that in order to remove the ampullary stone the sphincter of Oddi had, perforce, to be sectioned.

This empirical finding led to increasingly wide use of the operation of sphincterotomy for symptoms presumed due either to reflux of bile or pancreatic juice, so-called dyskinesia, resistance to flow of bile and pancreatic juice, or fibrosis of the sphincter. Whatever the background disturbance or the name given it, destruction of the sphincter muscle is an effective method for relieving symptoms.

As the two following articles point out, our understanding of the role of the sphincter of Oddi in the normal economy is that it regulates flow of bile and pancreatic juice into the duodenum, and by resisting flow of bile, it creates lateral pressure in the bile duct which fills the passive gallbladder. On this basis and with confirmation from experiments in the dog, it was considered that a normal gallbladder could not fill in the absence of resistance created by the sphincter of Oddi and would be a hazard after sphincterotomy.

The discussion in the two articles which follow is an attempt to thresh out the question: Should a normal gallbladder be removed in the course of section of the sphincter of Oddi?

J. H. M.

Gallbladder Function Following Sphincterotomy

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The admonition to remove the gallbladder, whether or not it is diseased, whenever the sphincter of Oddi is defunctionalized is based upon the assumption that it will become a flaccid diverticulum of the extrahepatic biliary tract and extremely susceptible to infection. In support of this view are the results of experimental work using dogs in whom the resistance to bile flow through the choledochoduodenal junction is reduced following sphincterotomy and the development of cholecystitis and cholangitis is both prompt and nearly universal. Furthermore, cholecystectomy performed at the time of sphincter section in this species has greatly reduced the severity of the ensuing cholangitis or prevented it altogether. However, the problem of infection aside, little attention has been directed toward the question of whether or not the sphincter of Oddi is necessary for gallbladder filling and function in either the dog or man. The fact that some animals, such as the horse and rat, who do not have gallbladders also lack sphincters of Oddi is suggestive but not conclusive evidence for a functional relationship between the two.

Manometric Studies

There are two methods available for the direct assessment of the effect of sphincter section upon the hydrodynamics of the biliary tract, namely manometry and cholecystography. The former has been used extensively in dogs. It has been found that the resistance to bile flow is reduced from approximately 150 mm. of water in the intact animal to 100 mm. of



Fig. 1. Cholangiographic study of gallbladder filling 33 days after sphincterotomy for recurrent pancreatitis. The common and cystic ducts filled immediately after the contrast material cleared the T-tube 12 minutes after starting the infusion at a rate of 3 ml./min. Flow into the duodenum was unobstructed

water following sphincterotomy. Necessarily the study of man has been less complete. Isolated measurements in an individual with an intact extrahepatic biliary tract[5] and in others after cholecystectomy and sphincterotomy have yielded similar values. However, data on the choledochoduodenal resistance in man with a normal gallbladder, before and after sphincter section, are not available. A limited, and as yet inconclusive, number of observations by the author in patients during the early postoperative period suggests that the resistance is lower when the gallbladder has been removed than when the operation has been performed without cholecystectomy.

Among the studies of biliary pressures, none was found that sought to demonstrate what pressure is necessary to fill the gallbladder. The reduction in resistance attributed to sphincter

section is only 30 to 50 mm. of water at most—no more than one-third of the total resistance. This may not be a physiologically significant decrease. Combined cholangiographic and manometric studies by Doubilet and his colleagues[2, 5] showed filling only of the major hepatic ducts in patients with prior cholecystectomy and sphincterotomy after the administration of morphine, in contrast to complete filling of the hepatic radicles in the intact patient. It was not demonstrated that a resistance sufficient to permit visualization of the intrahepatic ducts is necessary for filling of the gallbladder.

In two patients who had a transduodenal sphincterotomy for recurrent pancreatitis and in whom a normal gallbladder was spared, continuous pressure recordings have been made while a 50 per cent, water-soluble, radiopaque solution was infused through a T-tube into the common duct at a rate of 3 ml./min. under fluoroscopic observation. The cystic duct was



Fig. 2. Two minutes later the radiopaque solution outlined the major intrahepatic ducts and the ampulla of the gallbladder.



Fig 3. Thirteen minutes later, and six minutes after the administration of 10 mg of morphine sulfate subcutaneously, the gallbladder was completely opacified and the contrast material had disappeared from the hepatic ducts and duodenum

noted to fill immediately (Fig. 1). Although the major ducts were opacified before the gallbladder was visualized (Fig. 2)—perhaps because of dilution of the contrast material by the larger volume of bile in that organ—the fine intrahepatic ducts were never outlined. When the gallbladder was completely filled, in fact, even the major hepatic ducts were empty of radiopaque solution (Fig. 3). The measured common duct pressures and particularly the absence of a significant response to intraduodenal N/10 HCl attested to the completeness of the sphincterotomy.

Cholecystography

Oral cholecystography is a convenient means of confirming the ability of the gallbladder to fill following sphinc-

terotomy. The only study utilizing this technique in dogs was reported by Cadili and Sommariva.[1] In four animals the sphincter of Oddi was cut a distance of 1 cm. and then cannulated with a glass tube to insure continued incompetence. This apparently was not verified. Oral cholecystography 20, 60 and 90 days postoperatively demonstrated that the gallbladder functioned normally although not quite as well as preoperatively. Jones and Smith[3] attempted unsuccessfully to visualize the gallbladder in three patients following sphincteroplasty, an operation designed to render the choledochoduodenal junction incompetent and proved to do so in one case.

Seven consecutive patients in whom a normal-appearing gallbladder was preserved at the time of section of the sphincter have been studied personally by cholecystography during periods of observation extending from two weeks to two years. The ability of the gallbladder to concentrate the contrast material and contract in response to a fat meal has remained normal in five, as exemplified by Figure 4. The two with significantly reduced function, one examined two weeks and the other two years after operation, had reflux of barium into the common duct demonstrated on upper gastrointestinal x-ray study, indicating that the incision into the ampulla had included the duodenal musculature.



Fig. 4 Oral cholecystogram ten years before (*left*) and one year after sphincterotomy (*right*) for recurrent pancreatitis

Cholecystitis and Choledochitis

Preservation of the ability of the gallbladder to function after sphincterotomy would be of little importance if in man, as in dogs, infection of the biliary tree usually followed. Reports of two cases in which this complication developed have been presented by Large.[4] The onset of cholecystitis was noted "soon" after operation in one and "almost two years" later in the other. It was not stated what incidence these two patients represent or whether the sphincter section made the choledochoduodenal junction incompetent. On the other hand, four patients of Jones and Smith[3] remained asymptomatic during the three months to one year they were observed following sphincteroplasty without concomitant cholecystectomy even though reflux presumably was possible.

One of the seven patients studied here has been proved to have chronic cholecystitis two years following a sphincterotomy performed for nonspecific sclerosing choledochitis and cholangitis that had produced obstructive jaundice after a thirteen-year history of intermittent anorexia and pain initiated by homologous serum hepatitis. At the time of the first operation the gallbladder appeared normal although it had not been visualized on oral cholecystography. Reflux of barium into the common duct was demonstrated in the immediate postoperative period and again two years later at which time the gallbladder exhibited poor function by the oral test. Whether the cholecystitis resulted from the original disease or the operation is not clear.

While visualization of the gallbladder by cholecystography does not preclude the presence of mild chronic cholecystitis, the clearly normal x-ray studies and absence of symptoms suggest that the remaining six patients do not have biliary tract infection. It must be admitted that the period of observation in three is brief, being less than six months. On the other hand, two patients have been followed for a year or more.

Conclusions

It appears that in man the sphincter of Oddi is not necessary for filling of the gallbladder and that after sphincterotomy the resistance to bile flow offered by the intact circular muscle

layer of the duodenum suffices to accomplish this. Another source of resistance must be considered in the two patients in whom this mechanism was not operative because of overly extensive incisions that allowed reflux into the common duct. In these particular cases, this was considered to be partial obstruction of the common duct by biliary sediment in the patient who developed cholecystitis and by extrinsic pressure from residual pancreatic inflammation in the other.

The experience with these seven patients suggests that biliary tract infection is not an inevitable consequence of sphincterotomy in man, particularly if the duodenal musculature is preserved to prevent reflux. However, it would not be prudent to conclude that cholecystectomy is an unnecessary adjunct to sphincter section in view of the small number of cases and the brevity of the follow-up in many of them. Removal of the gallbladder ordinarily adds little to the operative procedure or its morbidity. Nevertheless, these observations are of interest because of the doubt they may cast on the importance of the sphincter of Oddi in gallbladder function and on the validity of transferring the results of animal experimentation to the human subject.

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Removal of the Normal Gallbladder at the Time of Sphincterotomy

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Nature has provided man with an efficient mechanism to prevent regurgitation of irritating or infected duodenal or intestinal content into the biliary tract. The rather complex anatomical configuration of the musculature of the common bile duct as it passes obliquely through the duodenal wall and empties through the ampulla of Vater and sphincter of Oddi into the duodenum serves not only as a one-way valve to prevent intestinal reflux, but also as an integral part of the mechanism for the filling and emptying of the normal gallbladder. For if no intraductal pressure is present, no gallbladder filling will occur. Thus it behooves any person bold enough to undertake a procedure such as section of the sphincter of Oddi to seriously consider its effects upon the biliary apparatus in general. This principle has recently gained considerable practical importance inasmuch as transduodenal sphincterotomy is now frequently employed in the management of patients with stenosis of the sphincter of Oddi or with chronic relapsing pancreatitis.

Animal Studies

In the course of experimental studies on bile duct reconstruction in dogs performed over the past few years in our laboratory, it was found that whenever the sphincter of Oddi was bypassed and the gallbladder left in place, a rather severe cholecystitis with the formation of concretions within the lumen of the gallbladder would occur. The common duct reconstruction was accomplished by choledochoduodenostomy or by the

anastomosis of a long blind Roux-Y loop of jejunum to the previously obstructed common duct. We were able to demonstrate that ascending infection occurred from the intestine up the lumen of the common duct; and that the gallbladder, which now could no longer function normally since the sphincter of Oddi had been bypassed, seemed to act as a blind pouch or nidus for the perpetuation of infection and indeed for its spread to other parts of the biliary tract including the liver.[1,2] Contrariwise, the animals who had had their gallbladders removed at the time of common duct reconstruction showed very little evidence of ascending infection, provided the choledochointestinal anastomosis remained wide open. It thus seemed to us that the continuous flow of bile in a downward direction along the biliary passages tended to prevent any significant degree of ascending infection from occurring, provided that no blind pouch or diverticulum such as the gallbladder was present in the biliary apparatus.

Clinical Experience

Since the biliary tract of the dog is anatomically much like that of man, it seemed reasonable to assume that a phenomenon similar to that described might occur in patients. Subsequent studies proved this to be true, and more recently a series of five patients with normal gallbladders who had either transduodenal sphincterotomy or transplantation of the common bile duct into the intestine and who had their gallbladders left in place, was reported.[3] All five of these patients were found at reoperation or at autopsy to have cholecystitis; and, in three of the five, gallstones had formed within the lumen of the gallbladder. Since the publication of this report, further instances of the development of this iatrogenic type of cholecystitis and cholelithiasis have been observed by us, and we feel it safe to conclude that whenever the common duct is anastomosed directly to the intestine or the sphincter of Oddi is cut and the gallbladder is left in place, it will become infected, stones are likely to form and symptoms are almost certain to occur.

At the present time we are studying another series of patients who have had vagotomy performed with either gastrectomy or gastroenterostomy for the treatment of complicated duodenal ulcer, and who have developed gallstones postopera-

tively. Following vagotomy, the sphincter of Oddi tends to become patulous so that regurgitation infection is possible. It will be interesting to determine whether or not such regurgitation through the open sphincter is really a factor in the development of gallstones in these patients.

Conclusion

In any case, on the basis of the experimental and clinical evidence which has already accumulated, it seems clear that the normal gallbladder should be removed whenever the sphincter of Oddi is cut or bypassed. If the gallbladder is not removed, it will tend to become inflamed, stones are likely to form and subsequent reoperation is likely to prove necessary.

It is thus our practice at the present time to remove the gallbladder whenever sphincterotomy is performed or whenever the common bile duct is anastomosed directly to the intestine The results to date seem to have amply justified the procedure; and persistent biliary tract infection, which used to be one of the frequent complications of these operations, has been pretty well eliminated in both the early and late postoperative periods.

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The Pathogenesis and Management of Pilonidal Sinus

Introduction

There have been two interesting features of the surgery for pilonidal sinus or cyst. One has been an apparent difference, in the results of operation, between those in military practice and those in civilian practice, the latter demonstrating ostensibly better results. There has been a tendency among surgeons toward wider and wider excisions; now, however, there is renewed interest in this condition because of a rather new concept of the pathogenesis of pilonidal sinus. This concept, which opposes the congenital or developmental etiology, swings the pendulum back to ultraconservative operations instead of ultraradical operations. The two following presentations support on the one hand the management by adequate operation (not radical), the other a new type of management (not ultraconservative).

S. R. F.

A Re-evaluation of the Pathogenesis and Appropriate Therapy of Pilonidal Sinus*

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The Congenital Theory of Origin

" 'Pilonidal' means literally a nest of hair In the midline on the posterior aspect of the sacrococcygeal junction there is frequently found a dimple which marks the site of attachment of the primitive neural canal. Occasionally a sinus is found at this site which extends into the soft tissues and often penetrates to the vertebral bodies. Closure of the external opening leads to the formation of a cyst, and infection results in a discharging sinus or an abscess. Secondary sinus tracts may form and give rise to multiple openings through the skin The sinus tract is lined by squamous epithelium in which hair is frequently found, however, suppuration soon destroys the epithelial lining. When the sinus is injected with methylene blue to mark its position and extent, it is sometimes found to penetrate the sacrococcygeal joint (Weeder) These deep extensions probably account for the frequent recurrences after attempted removal The position of the pilonidal sinus suggests an origin from the rudiment of the terminal part of the primitive neural canal About three-fourths of the cases occur in males, and symptoms develop most frequently in the second and third decades"

The foregoing statement was made in a textbook of pathology in 1956 [3] In 1954 Hopping[10] reviewed the literature since the first reported case of pilonidal disease in 1833. The congenital origin of these cysts was largely undisputed until fairly recent times, and no correlation was made between them and hair-bearing cysts of the umbilicus, for instance,[9] or hair-bearing implantation sinuses.

* Modified from Raffman, R. A : A Re-evaluation of the Pathogenesis of Pilonidal Sinus Ann. Surg. *150*·895–903 (Nov.) 1959

Evidence Against the Congenital Theory

Patey and Scharff[16] in 1946 questioned the congenital theory of origin by pointing out the clinical and pathologic discrepancies between the pilonidal sinus seen in adults and the exceedingly rare cysts and sinuses found in children.[16] Later they reported two cases of pilonidal-like sinus found in the interdigital web of barbers' hands.[17] Histologically, these were identical with sacrococcygeal pilonidal sinuses. There was no question of congenital origin in the hand, since the hairs found there in the sinuses were of different sizes, shapes, consistencies and thicknesses and came not from the barber but from the barbered. These sinuses were obviously acquired, and the authors pointed out that sacrococcygeal sinus could very well be of acquired origin also. Some of the pros and cons for the theories of congenital versus acquired origin may be found in several references: pro (24, 25, 3); con (11, 5, 6, 7). The true congenital dermal sinuses connecting with the meninges are discussed by Cardell and Lawrence[4] and Potter.[18] These will not be discussed here in detail. It should be pointed out that they are found almost exclusively in children, the sex ratio being about equal. The sites are various: sacral, lumbar, thoracic, cervical and cranial.

Appearance of the Disease After Puberty

In our own experience and that of others, the sacrococcygeal (pilonidal) sinuses are found exclusively after puberty, and the sex ratio is about 2:1, males to females. Hair follicles are not found in sacrococcygeal sinuses in adults, and are found in the congenital dermal sinuses of children.

No sacrococcygeal sinus was found in 10,000 surgical specimens at the Babies Hospital. A poll was therefore taken of the staff pediatricians, and also of the obstetricians at Sloane Hospital. Of the 32 who answered the questionnaire, not one could document a single case of sacrococcygeal cyst or sinus he himself had seen or treated in the newborn infant or the child. Sacrococcygeal dimples, on the other hand, were very common. These must not be confused with true sinuses. Dimples, of course, occur in other regions of the body where skin is fixed to underlying structures such as the cheeks, knees,

lumbar regions and along the spinous processes of the vertebral column. Sacrococcygeal dimples may predispose to the formation of pilonidal disease, but they do not imply congenital cysts.

Clinical Findings That Favor an Acquired Origin

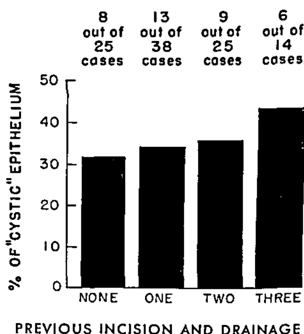
As far as the sacrococcygeal sinuses in adults are concerned, most of the present systems of surgical treatment are based on the premise that epithelium and hair follicles are present in the wall of the cyst or sinus and will remain there unless completely excised or exteriorized. The Presbyterian Hospital charts of 187 adult patients operated upon for pilonidal sinus between 1946 and 1957 were reviewed for past history. No pilonidal sinus had been found prior to symptoms, on routine examination, although ten of the patients had been born at Sloane Hospital and 22 patients had been admitted previously to the Babies Hospital at least once, and often several times. Thirty-four patients had had previous admissions to the Presbyterian Hospital. Twenty patients had had previous proctologic examination. Ten had passed physical examination for entrance to the Nursing School and three for entrance to the Medical School. Presumably each of these patients had had a relatively complete examination prior to the development of pilonidal disease. With all of these opportunities to document a congenital lesion, in only five cases were sinuses found on physical examination, and all of these were symptomatic. It seems improbable that an asymptomatic lesion was overlooked in 95 per cent of the cases. Military experience in World War II further emphasizes this point. Presumably every man passed one or more physical examinations before induction, yet over 77,000 cases of pilonidal disease later turned up in uniformed men.[8]

If we could find a patient who had no complaint other than a mass in the sacrococcygeal region, who had never had an operative procedure in this area, who had never had pain, discharge, etc., who, on physical examination, was found to have no evidence of external opening, whose surgical specimen on histologic examination showed a well-defined cyst lined with squamous epithelium associated with hair follicles, we would have little reason to doubt that this was indeed a congenital

lesion. Among our cases we found not one which met all these criteria, and most met not a single one. There was not one patient with a painless asymptomatic "lump," nor one case with an unequivocal closed cystic mass. If we exclude all patients with a history of previous operation or discharge, or with an external opening noted either by the surgeon or demonstrated by the pathologist, there remain two cases described grossly as "deep dimples." These were shown microscopically to be wide-mouthed epithelial-lined clefts with minimal inflammatory infiltration around the deepest portions. We have been unable to find even a single hair follicle which we could orient toward the deep or "cystic" portion of the sinus. This is in accord with the experience of Rogers and Hall,[20] Kooistra,[14] and Hueston.[11] These authors also found no lining epithelium in the majority of their cases.

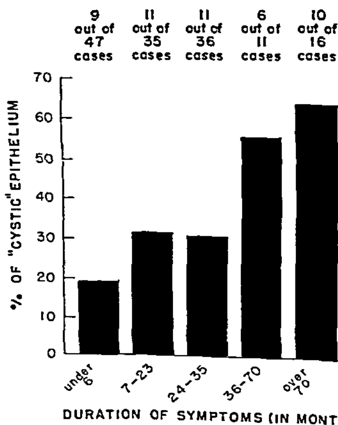
The Fallacy of "Buried Epithelium"

In our own material, sections of 187 pilonidal sinuses showed epithelium not connected with the epidermis in 29 per

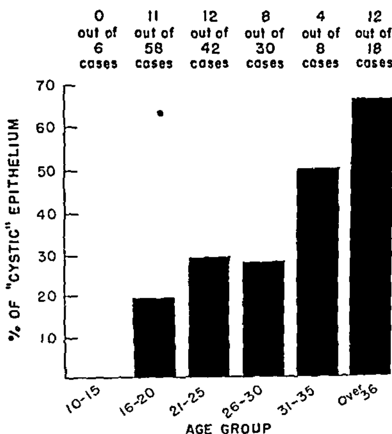


Graph I. Incidence of the presence of epithelium in the depths of the sinuses plotted against number of operations for incision and drainage.

cent. If we assume that, as a result of infection, the epithelium had been destroyed in the other 71 per cent there should be a correlation between loss of lining epithelium and duration and severity of infection. Presumably patients with the most operations for incision and drainage can be considered to have had the most infection. Graph I shows that patients never subjected to incision and drainage showed epithelium in 32 per cent of the specimens while those with three or more episodes of acute infection had epithelium in 43 per cent. Graph II plots incidence of epithelium against duration of symptoms. Graph III plots epithelium against age of the patient at the time of operation. Satisfactorily smooth curves can be drawn from each of these graphs to show that the incidence of epithelium in the depths increases with age, with duration of symptoms, and with severity of infection. This is at total variance with the premise we set out to examine, i.e., that the epithelium was there in the beginning but sloughed out as a result of infection.



Graph II. Incidence of the presence of epithelium in the depths of the sinuses plotted against duration of symptoms.



Graph III. Incidence of the presence of epithelium in the depths of the sinuses plotted against age of the patient at time of first operation.

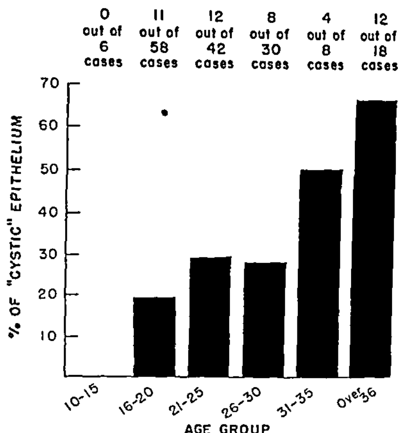
Finally, is there really any epithelium-lined "cystic" part at all? Although we found epithelium isolated from the surface in 29 per cent of our cases, this figure was derived by examining only one or two sections of each lesion. Further sections might have disclosed a connection between what we have called "cyst" epithelium and the epidermis. Unfortunately, most of our gross tissues were no longer available for further sectioning. The most recent 12 specimens, in which the total excision had been done and tissue was still available, were cut and embedded in blocks 0.5 cm. thick and multiple sections were made. Careful initial search revealed "cyst" epithelium in eight of these specimens. In these cases we continued to make sections until we were able to demonstrate an epithelial connection between the "cystic" portion and the skin epithelium in every case. In these instances, at least, we are certain that there was no isolated "cystic" part, that all deep epithelium did at some point connect with the surface epithelium and could have

grown down from it. It has been thought that after wide and deep local excision recurrence has been caused by bits of epithelium that had been left behind. In the study of our material we have no proof of this, and there are other factors which could account for recurrence.

Implanted Hair as the Etiological Factor

Let us consider again the reported pilonidal sinuses *not* in the sacrococcygeal region. Sinuses in barbers' hands,[17] in the axilla,[1] in the umbilicus,[9] and sinuses due to foreign material—cow's hair,[2] sheep's wool[15]—these are obviously not of congenital origin. Embedded hair is known to produce a foreign body reaction of a very persistent nature. Implanted hair is not phagocytized even two years after the experimental implantation.[11] Chronic foreign body sinuses are too well known to require further description, but the histologic resemblance between such sinuses and the pilonidal sinus must be emphasized.

Hair is the most common finding in all of our specimens (115 of 187). In our experience, in numerous instances of secondary breakdown healing has been prompt, sometimes after eight to ten months of persistent drainage, when removal of the hair and meticulous local care were instituted. Joseph and Gifford[12] stated that the tiny hair-containing sinuses they frequently found in barbers' hands could be treated by simply pulling out the hairs and allowing the sinuses to heal spontaneously. The condition is evidently so well known and considered so trivial among barbers and beauticians that they are accustomed to treat the lesions themselves, and resort to medical care only when some complication, which is rare, ensues. Treatment by x-ray as an adjunct to surgical treatment may be effective not by destroying "cyst" epithelium[21, 23] but by producing local epilation. Depilatory drugs have proved useful.[22] Klass[13] reports a conservative surgical approach to the disease. This consists of shaving the area, cleansing the intergluteal crease carefully and draining any focal infection by simple incision. Of 27 patients who had no other treatment, 23 have required no further treatment and four have required only minor care during three years of follow-up. Hardaway,[8] reporting in 1958 from the 97th Army General Hospital, using a regi-



Graph III. Incidence of the presence of epithelium in the depths of the sinuses plotted against age of the patient at time of first operation.

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men similar to that of Klass, states that in five years he has not seen a case which required excision.

If implanted hair is the etiological factor in pilonidal sinus disease the disease should be more common in men who are usually more hirsute than women, and it is, 2:1. It is also more common in hirsute races.

Our interpretation, therefore, of the sacrococcygeal sinus is that at puberty the hair in the intergluteal cleft becomes thick and stiff. Local repeated trauma to the sacrococcygeal region is common in adolescence. Poor local hygiene, as in soldiers on active field duty, allows perspiration, sebaceous material, and desquamated epithelial cells to accumulate in this cleft, to say nothing of fecal material. The skin becomes macerated in the depths of the cleft. The abrasive properties of short pieces of stiff hair are well known. Continued trauma could force these bits of hair through the softened skin. The implanted hair shafts would then set up a foreign body reaction. Epithelium might grow down along the tracts of the shafts. The patient might have little or no discomfort for some time. However, in our series of 187 cases, 67 per cent of the women and 47 per cent of the men had symptoms by the age of twenty years.

Repeated trauma probably further embeds the foreign bodies, the hairs, in the depths. Infection then may lead to a deep abscess which can be indolent and become quite large. Thus the misconception of its origin in a pre-existing deep cavity or cyst is understandable.

A New Approach to Treatment

Since body hair, not buried epithelium, is the villain of the piece, one must now seek a new hero. Prevention of pilonidal disease becomes a problem for the family physician. The surgeon may stand by to perform incision and drainage, removal of foreign material and local excision of epithelized sinus openings when the disease gets out of hand. Adequate personal hygiene and removal of hair in the intergluteal crease by suitable means should become the chief objectives in the prevention and cure of this condition. In obese, hirsute individuals these measures are especially important if a deep dimple is present in the intergluteal cleft.

Conclusion

In conclusion, we believe that there are no pilonidal cysts, only sinuses; that the disease is acquired, *not congenital*; that it appears after puberty, not before; that hair, not buried epithelium, is the primary pathogenic agent. Pilonidal sinus is an acquired chronic foreign body sinus. It is analogous to the acquired sinus seen in barbers' hands, is preventable, and can be cured by local conservative therapy.

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The Selective Treatment of Pilonidal Sinus

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The most remarkable feature of the pilonidal sinus has been its ability to generate immoderate disagreement concerning etiology and management. The abnormality ordinarily involves only the skin and subcutaneous tissue of the sacral area and does not endanger life, yet its treatment has remained a source of controversy among surgeons.

Almost every paper in the extensive pertinent literature suggests that it is usual for the surgeon to treat all patients by the particular procedure advocated without regard to the extent or manifestations of the disease in the individual. This is unreasonable if proper consideration is given to the pathogenesis of the particular lesion. A proper respect for invasive infection is the only concession generally made to the individualization of the management.

The wearisome technical details of the variety of operations offered as the solution to this problem are readily available. Those not violating surgical principles may have occasional application; none can always be used.

Undoubtedly the plucking of a few hairs from a shallow sinus tract is sufficient treatment in some instances; in such circumstances an extensive plastic revision of the area would be foolhardy. On the other hand, limiting treatment to removing the encysted hair from an area of tissue chronically infected, riddled by multiple, long-infected sinus tracts, and irreparably damaged by extensive fibrosis would be equally ill advised. Treatment should be individualized and designed to eliminate the abnormal tissue with the minimal sacrifice of normal tissue. Judgment is required in the selection of the method to accomplish this.

Surgical Considerations

Hospitalization, preoperative preparations and anesthesia are dependent upon the anticipated procedure. Generally the advantages of excision of the abnormal tissue from an undistorted field indicate the use of an anesthetic other than field block or local infiltration. This in turn usually requires hospitalization. The consequent further advantages of hospitalization can be appreciated.

Excision of uninvolved skin is undesirable from all aspects. Only that skin directly involved by the sinus openings is diseased. Sinus openings through the skin must be connected but the sacrifice of normal skin by an excision of an elliptical area in order to encompass all sinus openings is in violation of the significant principle of preserving all undamaged skin. The dissection of all abnormal tissue from the subcutaneous space may involve the removal of considerable tissue. This requires direct vision in a clean field with dissection by a knife. The precise recognition of differences in tissue density cannot be appreciated with scissors or by blunt dissection. Absolute control of all bleeding points with suture ligatures of fine chromic catgut assures a dry wound.

Obliteration of the resultant space is best accomplished by multiple layers of fine catgut. Nonabsorbable sutures placed in the subcutaneous tissue over bone prominences exposed to pressure commonly form tender nodules and are eventually sloughed through the skin. The use of only fine suture material assures closure without excessive tension. The suture layers are not primarily directed from one side to the other, but from the subcutaneous tissue to the sheath of the gluteus maximus and sacral fascia, eventually reaching the dermal layer on either side. The skin usually will reach the midline and can be approximated under these circumstances, for none has been unnecessarily sacrificed. If it does not reach the midline without difficulty the remaining area is left to epithelize by contraction and ingrowth of epithelium from the margins. The insistence upon closure invites failure to heal. Always leaving an unclosed cleft results in unnecessary morbidity.

Obliteration of space and approximation of tissues is the function of the sutures placed by the surgeon, not of the surgical dressing. Contrary to most other instances, the dressing

should be changed frequently in order to meet the special problem of moisture in the gluteal cleft and soiling from anal discharges. Medication designed to alter bowel function serves no useful function.

It is conceivable that very extensive plastic operations, similar to those required for decubitus ulcers, may be rarely required. Their planning should be conducted with the same attention to general principles.

Summary

A rigid attitude toward the method of treatment of the pilonidal sinus of a patient should be abandoned. The surgeon should not adhere to a preconceived plan but should modify the treatment with respect to the problem and the application of the proven principles of surgery.

Carcinoma of the Breast

Introduction

The discussion of the choice of treatment for carcinoma of the breast which follows is an extension of controversial points presented in Volume I.

In a way, Doctor Haagensen's statement may be considered an extension of a controversy which has gone on in the general literature for almost a hundred years. The trend of contentions is traceable through quotations. In 1875 Volkmann extended operation for cancer of the breast by excising the fascia over the pectoralis major muscle. He wrote regarding permanent cure by operation: "I unhesitatingly make this statement for all cancers (of the breast), that when a whole year has passed and the most careful examination can detect neither a local recurrence nor swollen glands, nor any symptoms of internal disease, one may begin to hope that a permanent cure may be effected; but after two years usually, and after three years almost without exception, one may feel sure of the result."

Billroth differed: "I think one may express himself more boldly and may declare that if the careful examination of an experienced surgeon detects no recurrence when one year has passed since the operation, one may be sure that there will be neither a local nor glandular recurrence and may pronounce the patient as radically cured." Billroth provided retreat bridges in the words "careful" and "experienced" of this declaration but did so more obviously in another tenet of his which was cited by Halsted: "As regionary recurrence (to be distinguished from local recurrence) Billroth designated a return of the cancer in or about the scar 'after a long time.' Recurrences after so long a time (presumably one and one-half

years) he regarded as growths de novo and as absolutely independent of the original growth. To explain these late recurrences he assumes a cancer diathesis (a familiar refuge?), or that conditions favorable to the development of cancer have been furnished by the scar."

The story advanced in 1889 by extension of the operation to *include both pectoral muscles and axillary contents*, a proposal which Halsted and Willy Meyer made independently. Halsted states in a report entitled "The Results of Operations for the Cure of Cancer of the Breast Performed at the Johns Hopkins Hospital from June, 1889 to January, 1894" that "In every one of the 50 cases some or all of the axillary glands were cancerous. It is stated in the histories of 17 cases that the highest infraclavicular gland was involved. In only seven cases, is it recorded that the highest glands were not involved."

Halsted in 1907 reported on "Cured Five-Year Cases." Of 204, 59 or 30.89 per cent were "cured." There were ten patients, however, who were listed as "cured, dead," and 13 under "postoperative death and lost to follow-up"—a total of 23 not considered in the computation of "percentage cured."

Extension of the operation to supraclavicular node-bearing tissues *was tried, evaluated, and discarded. In a paper read* before the American Surgical Association in 1907, Halsted cited Handley about cancer cells in the blood stream being destroyed or rendered harmless!

We have completed the full turn of mind about treatment several times in six decades. It is a curious and lasting statistical fact that the five-year "overall" survival rate is the same today as it was in 1894.

Treatment is now based on how cancer of the breast behaves. Final judgment will come only when we know what cancer of the breast is.

J. H. M.

The Choice of Treatment for Breast Carcinoma

C. D. Haagensen

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The inquiring student of breast carcinoma is today distressed by the sharply opposing views regarding the treatment of the disease. On the one hand are the surgeons who have labored in the vineyard perfecting the radical mastectomy which they apply in from 75 to 93 per cent of their patients. On the other hand are the radiologists, some of whom, like Dr. McWhirter, wish to abandon radical mastectomy entirely and treat all breast carcinomas with irradiation, often in combination with some kind of local limited surgery. These two antipodal points of view are championed with such sincerity in futile tournaments of rhetoric (see Bergson et al., 1957 and 1958 vs. McWhirter, 1958) that one is reminded of medieval knights belaboring each other but inflicting no damage because of the complete protection their armor gives them. The opponents in the contest over breast carcinoma are protected by their intellectual intransigence. The surgeons resolutely stick to their operation because they know from experience that it sometimes succeeds amazingly well. The radiologists stoutly claim that their "five-year survival rate" equals that of the surgeons.

Absolute Survival Rates as a Measure of Achievement

The basic fact which all schools of therapeutic opinion must face up to is that the results of all aggressive methods of treatment are rather similar if expressed in absolute terms. By *absolute* terms I mean that the total number of patients with primary (previously untreated) carcinoma of the breast coming to the hospital in question, is used as a basis in computing the survival rate. No deductions of any kind are made. No easy

classification of cases as determinate or indeterminate is permitted. At Columbia we have reported our results since 1915 in absolute terms. McWhirter computes his results in this manner and states that they represent "the survival rate of all patients who develop breast cancer in south-east Scotland," since all eventually come to be registered in his Edinburgh clinics. There can be no doubt that such absolute survival rates best represent the overall comprehensive achievement in the control of the disease. The similarity of these absolute survival rates in different clinics with widely different therapeutic methods is shown in Table 1.

This similarity of absolute results can be explained by the fact that in the majority of patients with breast carcinoma the disease is comparatively advanced. In these patients with advanced disease it makes but little difference which method of aggressive treatment is used—all usually fail. In computations of results of treatment the leveling influence of failure in these more advanced cases tends to hide any advantage that any

TABLE 1. ABSOLUTE SURVIVAL RATES FROM VARIOUS HOSPITALS

Years Covered by Study	*Author and Year of Publication*	*Hospital*	*Total No. of Primary Cases*	*Absolute 5-Year Survival Rate**	*Absolute 10-Year Survival Rate**
1936–1941	Nohrman, 1949	Radiumhemmet, Stockholm	1042	40 1%	23 4%
1937–1944	Smithers, 1952	Royal Cancer Hospital, London	1093	34 6%	20.7%
1936–1942	Windeyer, 1949	Middlesex Hospital, London	917	34. %	20 7%
1931–1944	Nielsen, 1951	Copenhagen Radium Centre	1405	38. %	18. %
1930–1939	Williams et al , 1953	St. Bartholomew's Hospital, London	1044	34 %	20. %
1936–1947	Bryant et al , 1954	University of Michigan Hospital, Ann Arbor	742	40.2%	
1935–1942	Haagensen and Stout, 1948	Presbyterian Hospital, New York	668	47.9%	33 4%
1941–1947	McWhirter, 1955	Royal Infirmary, Edinburgh	1882	42. %	25. %

* *Number of survivals expressed as a percentage of the total number of primary cases.*

special method of treatment may have in the earlier cases. Our experience has shown that in approximately 50 per cent of women with breast cancer the disease has already extended beyond the reach of both radical mastectomy and local irradiation. Their local disease can usually be held in check by either of these methods, but distant metastases eventually defeat us. The cures that are obtained will all be in the 50 per cent of patients with earlier disease.

The Real Question

It is therefore toward the problem of treatment of the patients with comparatively early breast carcinoma that we must direct our attention. The one question which all surgeons and radiologists should today be asking themselves is, "What is the most successful method of treating early and curable cancer of the breast?" McWhirter is surely wrong when he assumes that the answer can come from comparison of absolute or overall survival rates such as he presents. The answer to this question can come only from comparative studies of the results of different methods of treatment in meticulously staged series of earlier cases.

A Clinical Method of Staging Breast Cancer

The method of staging used must be precise enough to *make the series truly comparable, and simple enough to make* it practical. The staging must of course be on a clinical basis because no microscopical data regarding the state of the axillary lymph nodes are available in the cases treated solely by irradiation. The Manchester system of staging, extensively used in Britain, is perhaps the best of several currently popular systems, but it is not precise enough in its description of the earlier group of cases, the very ones in which we are most interested. The system of staging put forward by the International Union Against Cancer is hopelessly complex and confused. At Columbia we have been working at the problem of the clinical classification of breast carcinoma for many years, because it has been on the basis of clinical criteria that we have, until recently, selected our patients for operation. We are perhaps in a better position than others to devise a satisfactory method of

TABLE 2. A CLINICAL METHOD OF STAGING BREAST CANCER

Group	*Clinical Findings*
A	No grave signs of locally extensive disease Axillary lymph nodes not clinically involved
B	No grave signs of locally extensive disease. Axillary lymph nodes clinically involved but less than 2.5 cm. in transverse diameter and not fixed to the overlying skin or the deeper structures of the axilla
C	One of five grave signs of extensive disease is present: 1. Ulceration of the skin (excluding Paget's disease) 2. Edema of the skin of limited extent (less than one-third of the skin over the breast) 3. Solid fixation of the primary tumor to the chest wall 4. Axillary lymph nodes 2.5 cm. or more in diameter 5. Fixation of axillary nodes to overlying skin or deeper structures of axilla
D	All other advanced cases

clinical staging which will define the earlier cases. Dr. Edith Cooley, our statistician, and I have worked out the classification given in Table 2 which divides breast carcinomas into four groups.

There are several features of this classification worth emphasizing. No limits as to the *size* of the primary tumor are stated. We have found this feature to be of lesser importance. *Edema* of the skin is a sign of great prognostic significance, because it means that the subdermal lymphatics are full of tumor emboli. Edema is often missed when it is of slight extent and localized to the areola and the central portion of the skin over the breast Only those cases in which the edema involves less than one-third of the skin are placed in our Group C; all those with more extensive edema are put in Group D. *Solid fixation* as we define it means that the primary tumor is solidly fixed to the underlying thoracic wall. Most breast carcinomas are fixed to some degree in the surrounding breast tissue which is, nevertheless, movable over the thorax: this is not what we mean by solid fixation.

By *clinically involved* axillary lymph nodes we mean lymph nodes which a skilled examiner would classify as containing metastases. For example, it may be said that the presence of one or two very small 5 mm., not particularly firm, movable nodes in an axilla is not an indication of metastasis,

but a firm 1 cm. node usually means axillary involvement. Some authorities, among them McWhirter, claim that all clinical staging based upon the findings of axillary palpation is so unreliable that it is not worth attempting. It is my own experience, however, that the findings of reasonably skilled clinicians in axillary palpation will be very similar, and that it *is* possible to classify cases on this basis as suggested in our plan for clinical staging. It is of course understood that all examiners make an error of between 30 and 40 per cent in their clinical estimates of axillary involvement; that is to say, axillary metastases actually exist in 30 to 40 per cent of patients in whom the axilla seems to be clinically uninvolved and who are therefore classed in our Group A. But when different series of cases in which this same method of clinical staging has been used are compared, the error cancels out because it is similar in all the different series. The only requirements are that the series be large enough, and that the staging be done by reasonably skilled examiners.

It should be pointed out that our method of clinical staging emphasizes the distinction between the different groups of earlier cases. The cases in Groups A, B and C are all within the limits of operability as we have defined them by our clinical criteria in years gone by. All of the far advanced cases, such as those with the inflammatory type of breast carcinoma, those with supraclavicular metastases, and distant metastases, are lumped together in Group D. We are not interested in further classification of these advanced cases. In them the disease is incurable and all methods of treatment unsatisfactory.

Results of Radical Mastectomy in a Staged Series of Cases

We have studied our results with radical mastectomy in a personal series of cases staged in this manner (Table 3). All of the radical mastectomies that I have done myself or assisted my resident surgeons with, between 1935 and 1952, have been included in this series: none has been omitted from this report. There have been no operative deaths and no patients lost to follow-up.

THE QUESTION OF "SELECTION." The immediate reaction of some critics to these data is to object that these cases have been "selected." It should be clear to all, and I hasten to re-

TABLE 3. RESULTS OF RADICAL MASTECTOMY
Personal Series (1935–1953)

Clinical Group	*Number of Cases*	*Micro. Axillary Met.* Per cent	*Local Recurrence* Parasternal	Local	Per cent	*5-Year Survivals* Number	Per cent
A	227	35.7	8	6	6.2	187	82.4
B	115	77 4	5	15	17.4	66	57.4
C	46	76 1	4	11	32.6	18	39.1
D	12	100 0		7	58.3	3	25.0
TOTAL	400	54 2%	17	39	14.0%	274	68.5%

emphasize, that *selection* is the basis—indeed, the very heart—of our effort to improve our treatment of breast carcinoma. Ideally, I wish to select for radical mastectomy only those patients whom the operation will cure, and to treat all others by irradiation. I feel strongly that operation performed futilely does harm. Sometimes the harm is physical due to the surgeon's dissection actually spreading the disease and hastening death. And there is always an emotional penalty for the mutilation which the operation entails.

With the *clinical criteria of operability* which were the basis of my selection of cases during the years 1935–52, reported in the above table, I was far from achieving this ideal selection. The five-year survival rate was only 68.5 per cent. The criteria selected Group A cases fairly well, but did very badly with Groups C and D cases. I am today convinced that Groups C and D cases should not be treated by radical mastectomy and that irradiation is preferable in them.

Regional Lymph Node Biopsy Method of Selection of Cases

In 1952, searching for a better method of selection, we began to perform regional lymph node biopsies. We had learned from our studies of the natural history of breast carcinoma, and from Handley's investigation of the internal mammary lymph nodes and Dahl-Iversen's dissections of the supraclavicular lymph nodes, that occult metastases were often present in these portions of the regional lymph node filter. Their presence of course makes conventional radical mastectomy an inadequate and futile procedure. We at first combined supraclavicular dissection with removal of the internal mammary nodes in the

upper three interspaces, carrying these dissections out as a separate preliminary operative procedure for the purpose of determining whether or not the patient's disease was limited enough to make radical mastectomy reasonable. After several years' trial, we abandoned supraclavicular dissection and substituted for it biopsy of the apex of the axilla, because we found that the disease in some patients had reached the *subclavicular* nodes and was therefore incurable by operation, although it had not yet involved the *supraclavicular* nodes. Patients in whom the lymph nodes at the periphery of the regional lymph node filter were found to contain metastases were not operated upon, but were treated by irradiation only.

We do not perform these preliminary regional node biopsies on all patients; we have learned as our experience has grown how to pick out the patients in whom these regional nodes are likely to be involved. We have now done internal mammary biopsies in more than 600 cases and apex of axilla biopsies in more than 200. Our findings are shown in Tables 4 and 5. It is obvious from these data that these regional lymph node biopsies have saved a great many of our patients from futile radical mastectomy.

We had not developed the regional lymph node biopsy method of selection at the time the cases shown in Table 3 were selected for radical mastectomy. In a few years more, when we are able to present results in cases selected by a combination of our clinical and regional lymph node biopsy criteria of operability, our operative results will of course be further improved. The more accurate our selection, the closer we will get to our ideal of selecting only curable cases for radical mastectomy.

TABLE 4. CARCINOMA OF THE BREAST—INTERNAL MAMMARY BIOPSIES
Presbyterian and Francis Delafield Hospitals (1951–1957)

Result of Biopsy	*Central and Inner Half of Breast*		*Outer Half of Breast*		*Total Cases*	
	Number	Per cent	Number	Per cent	Number	Per cent
No internal mammary metastases	189	62 2	159	81 1	348	69.6
Internal mammary metastases	115	37.8	37	18.9	152	30.4
TOTAL	304	100 0%	196	100.0%	500	100.0%

TABLE 5. CARCINOMA OF THE BREAST—INTERNAL MAMMARY AND APEX OF AXILLA BIOPSIES

Presbyterian and Francis Delafield Hospitals (January, 1955–July, 1957)

Group	Classification of Cases	Number of Cases
1	Neither internal mammary nor apex of axilla nodes involved.	65
2	Both internal mammary and apex of axilla nodes involved.	13
3	Internal mammary nodes involved; apex of axilla nodes uninvolved	10
4	Internal mammary nodes uninvolved, apex of axilla nodes involved	12
	Total cases with triple biopsy . 100	
	Total internal mammary nodes involved. . 23*	
	Total apex of axilla nodes involved 25	

* *This does not represent the true frequency of internal mammary metastases found in our studies, because the patients who had internal mammary biopsy only are not included here.*

The Need for Comparative Studies in Early Cases

For the moment we must attempt to learn which method of treatment succeeds best in the earlier and curable cases. Using the method of clinical staging which we have suggested above, it is possible to study the results of different methods of treatment in truly comparable series of early cases. We have such a comparative study under way and have high hopes that it will teach us something. Those who propose to abandon radical mastectomy and substitute something else for it have a special obligation to make this kind of comparative study. They include the surgeons who are content to perform only simple mastectomy, ignoring the challenge that possible involvement of axillary lymph nodes presents. There is ample proof that axillary metastases, if they are not too extensive, can be successfully dissected out surgically. The results in my personal series of cases with axillary metastases are shown in Table 6.

TABLE 6. RESULTS OF RADICAL MASTECTOMY IN PATIENTS WITH MICROSCOPICALLY INVOLVED AXILLARY NODES

Personal Series (1935–1952)

Number of Nodes Involved	Number of Cases	Number of 5-Yr Survivors	Per cent of 5-Yr. Survivors
1 or 2	84	61	72 6
3 to 7	67	35	52 2
8 or more	66	18	27 3
TOTAL	213	111	52 1%

The Status of Irradiation in Early Cases

The most serious challenge to radical mastectomy is of course that of the radiologists. Not content with treating only the more advanced cases, some, like McWhirter, claim the early cases as well. I am not familiar with any data which indicate that irradiation succeeds, in terms of five-year survival, as well as radical mastectomy in the early cases staged A and B in our classification. And the measure of five-year survival is probably not an adequate one. Irradiation locks carcinoma up in a fibrous prison from which it occasionally breaks free after five years. Ten-year survival without clinical evidence of persisting disease is a much more reliable index of the succcess of irradiation, and it may well be that it will be necessary to resort to comparison on this basis before the answer is apparent to the question of how best to treat early carcinoma of the breast.

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Gastric Suction and Early Operation Versus Intestinal Decompression and Delayed Surgery in Small Bowel Obstruction

Introduction

Few problems in surgery demand more specific know-how and individual attention to detail than those relating to intestinal obstruction. Furthermore, the morbidity and mortality remain high, when compared with other acute abdominal conditions, despite the many advances in both medical and surgical practice. It seems advisable, therefore, for each of us to re-evaluate and compare our own plan of management with those advocated by others with particular attention to the details of controversial areas so as to assure complete understanding of the method(s) proposed, the reasoning behind the method and the results to be anticipated.

Techniques permitting continuous intestinal siphonage and in turn decompression of the small intestine have become important adjuncts to the management of patients with intestinal obstruction. The rationale for long tube suction in the treatment of paralytic ileus or in patients too ill to withstand operation is well granted. In addition, the majority of practicing surgeons will resort to its use when the diagnosis is uncertain or doubtful. Similarly, it is generally agreed that operative intervention is usually required in patients with acute mechanical obstruction of the small bowel, and the utilization of the long intestinal tube as a means of releasing the obstruc-

tion without operating has fallen into disrepute. There are, however, considerable differences of opinion as to the necessity for and/or the degree of preoperative decompression required when an operation for acute obstruction of the small intestine is planned.

Those advocating routine intestinal intubation by means of a long intestional tube as a preliminary to definitive surgery point out that the relief of distention provides additional time for a more careful evaluation of the patient and treatment of the dehydration and electrolyte loss. Certainly decompression of the distended bowel, when achieved, makes for an easier operative procedure. Furthermore, a useful safety valve has already been provided for those patients requiring resection or likely to develop a prolonged postoperative ileus.

Those advocating simple gastric or gastroduodenal suction and earlier operation point out the difficulties of successful intubation of the small bowel, particularly in the small community hospital with few or no trained ward or x-ray personnel. Furthermore, preoccupation with passage of the tube diverts attention from needed replacement therapy. In addition, they emphasize that intubation if successful and accompanied by progressively decreasing distention does not lessen the likelihood of finding a strangulated bowel if operation is delayed too long. Finally, aseptic decompression may be accomplished at operation and a supplementing ileostomy serves as a satisfactory adjunct if prolonged postoperative ileus is anticipated.

The controversy is an interesting one and undoubtedly results in part from varied experience and ability in intubating the small intestine. The reasons for and against each method are well presented in this section and the final choice of procedure or combinations of approach will have to be made by the reader. It should be kept in mind, however, that the finding of a strangulated obstruction requiring resection is just as serious regardless of decompression methods, and delay therefore must be avoided at all costs.

E. H. E.

Gastric Suction and Early Operation for Small Bowel Obstruction*

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Intestinal obstruction is a common surgical problem and one which can challenge the surgical judgment of the most alert clinician.[7-14] Furthermore, the morbidity and mortality of acute intestinal obstruction remains relatively high when compared with other acute abdominal diseases, in spite of the general improvements in medical and surgical practice.[1, 3, 15] Finally, in a population of increasing longevity, these problems will assume a place of even greater importance, since malignant tumors or operations for their removal are leading causes of obstruction and it is in the elderly that gastrointestinal cancer reaches its peak.

Five hundred and ninety-two consecutive cases of intestinal obstruction seen during the past ten years have been statistically reviewed in order to evaluate the effectiveness of our plan of management. The results of this study will be presented and the therapeutic regimen which has evolved in attempting to lower the residual mortality will be described.

Etiology

Four hundred and fifty-four (76.7 per cent) of the 592 cases were obstructions of the small bowel and the remaining 138 involved the large bowel. The detailed causes of small bowel obstruction were many and varied; however, over one-half or 235 of the 454 resulted from adhesions or bands, usu-

* The conclusions presented in this paper were arrived at from a statistical study of patients admitted to the University Hospital, Columbus, Ohio, with small bowel obstructions

ally postoperative. Forty-nine or 8.3 per cent of the entire series occurred during the immediate postoperative period and resulted from herniation through a dehisced wound or as a complication of prolonged postoperative ileus. Volvulus was noted in 16 instances. External hernia, especially inguinal and femoral, was the second most common cause and accounted for 98 of the 454 obstructions of the small intestine—nearly one of every five. Internal hernia occurred in only five instances. There were 35 instances of malignancy (7.7 per cent), the majority being metastatic in origin. The remaining mechanisms, in order of frequency, included regional enteritis, 2.6 per cent; vascular occlusion, 2.9 per cent; gallstone ileus, 1.5 per cent; and intussusception, 1.3 per cent. Congenital lesions were implicated in only four instances, Meckel's diverticulum in one, and congenital peritoneal bands in three.

Importance of Early Operation

Mortality figures in the literature of recent years have ranged from as low as 4 per cent to well over 20 per cent.[5, 10] Mortality in the present series varied with the site of obstruction, and averaged 8.7 per cent in involvement of the large bowel and 9.7 per cent in involvement of the small intestine, with an average mortality of 9.4 per cent.

A previous review of small intestinal obstruction seen in the University Hospital during the period 1946–1948 had shown an overall mortality of 19.6 per cent and an operative mortality of 21.6 per cent, a fatal termination in one of every five cases. Although these end results compared favorably with other clinics at the time and represented a considerable improvement over that noted for previous years, an analysis of the factors contributing to this residual mortality was deemed advisable.

During these years we had concerned ourselves with routine intestinal intubation by means of the Miller-Abbott long intestinal tube as a prelude to definitive surgery. When successful and accompanied by progressive relief of distention, this plan had seemed to provide additional time for a more careful evaluation and treatment of dehydration and electrolyte depletion, and in certain instances made for an easier operative procedure. Furthermore, a useful safety valve had already been

provided for those patients requiring resection or likely to manifest a prolonged postoperative ileus. And, finally, complete relief of obstruction had been realized in the occasional patient without operative intervention.

The rationale for long tube suction, therefore, seemed well grounded. However, a critical review of the hospital records demonstrated several items limiting its usefulness. First of all, despite the use of recommended postural and gravitational techniques combined with frequent and repeated fluoroscopic observations, intubation of the small bowel was successful in only one-half of the patients. Of equal importance, preoccupation with passage of the tube diverted attention from needed replacement therapy and frequently allowed the optimum time for operation to pass. Furthermore, successful intubation and constant suction drainage not infrequently failed to release the obstruction, with the finding of a strangulated bowel at the time of delayed operation. As a matter of fact, impaired blood supply was noted in 22.1 per cent of all patients operated upon and in them the mortality following resection exceeded 30 per cent.

A statistically significant improvement in the percentage of successful results was realized during recent years. The incidence of gangrene fell to only 1 in 10 cases, the mortality following resection for gangrene was decreased by one-half, and the overall operative mortality approximated 4 per cent. Although a number of factors were undoubtedly concerned, such as improved replacement therapy and chemotherapeutic and antibiotic agents, the improvement in the end results is best ascribed to earlier operation. During this period, intestinal intubation was abandoned in favor of gastric suction, vigorous fluid, electrolyte, and whole blood replacement, and finally, early operation. It is our purpose to describe this plan of management, which has proved safe and effective in our hands during recent years.

Plan of Management

Emergency hospitalization is indicated whenever obstruction is suspected, since replacement or supportive therapy should be started and immediate steps taken to assure a prompt and accurate diagnosis. Having reviewed the outstanding facts

in the patient's immediate illness, the examiner seeks information regarding previous abdominal surgery or recent weight loss since postoperative adhesions and malignant tumors or operations for their removal account for the majority of obstructions.

Baseline observations should include an accurate measurement and recording of the initial pulse rate for several reasons. In the first place, the pulse rate is a most reliable admission sign with regard to the expectancy of finding gangrenous bowel at the time of operation. In a recent review of 106 cases of small bowel obstruction, an impaired blood supply was noted in four times as many patients with an admission pulse rate above 100 when compared with those with rates below this critical value.[12] A direct correlation between the admission pulse and the ultimate outcome of treatment was also demonstrated, inasmuch as three times as many cases with an elevated pulse rate terminated fatally. Finally, repeated observations of the pulse during replacement therapy enable the clinician to estimate the patient's response to treatment and, having realized maximum benefit, he may proceed more safely with operation.

Having evaluated the patient's general condition, the physician should complete a careful survey of the abdomen, noting the degree and extent of distention and the position of old operative scars. The finding of an incarcerated external hernia, the palpation of an abdominal mass and, more especially, the demonstration of an area of maximum tenderness may well indicate the exact site of the obstructing lesion. A careful pelvirectal or rectal examination noting the presence or absence of a palpable mass and the consistency and the color of any residual feces completes the examination.

If vomiting or abdominal distention is in evidence, a slightly larger than average caliber, short gastric tube is introduced into the stomach and, after evacuation of residual contents with a hand syringe, is attached to a constant suction apparatus. A complete blood count and urinalysis is obtained and, using an 18 gauge needle, a sample of venous blood is collected for immediate cross-matching and baseline blood chemical tests (blood urea nitrogen, chloride, carbon dioxide and, if available, sodium and potassium). The routine measurement of the blood amylase serves to exclude the presence of

acute pancreatitis. Since large amounts of sodium chloride are lost into the distended bowel, the initial infusion should contain normal saline and, for the patient's comfort and for simplicity, is best started immediately following collection of the blood samples noted above and given through the needle used for the initial venipuncture.

Fluid Requirements

Information as to the duration, frequency and severity of vomiting gives some estimate as to the degree of dehydration and the amount and type of fluid needed for its correction. These facts, together with the dryness of the mouth and tongue, the inelasticity of the skin and, more especially, the volume and specific gravity of the first urine specimen should enable the physician to classify the patient's state of dehydration as mild, moderate, or severe. The subsequent urine output and particularly the change of its specific gravity following the initial infusion are most helpful in determining the adequacy of fluid therapy.

If urine production is sufficient, and in the absence of renal disease, 30 to 60 mEq. of potassium chloride (2.23 to 4.46 grams) are added to the second liter of 5 per cent glucose in normal saline.[8] Although the fluid requirements in four of every five instances are satisfied by these 2,000 cc. of 5 per cent glucose in normal saline, this amount is best regarded as a working estimate only and the actual intake is regulated by the urine output and the pulse rate. When the results of the laboratory work are available, an adjustment of the proposed electrolytes may be required. A transfusion of 500 cc. of whole blood completes the usual preparation and, when maximum response has been attained, one should proceed with operation.

Importance of Whole Blood

The importance of blood replacement has been emphasized in a study of 27 patients hospitalized with intestinal obstruction.[9] These patients demonstrated an average admission blood volume deficit of 1,200 cc. Plasma loss exceeded red cell loss and varied directly with the duration of the obstruction:

one to two days, 27 per cent deficit; three to four days, 37 per cent deficit; and over four days, a 40 per cent deficit. The average whole blood requirement in the entire series exceeded 1,000 cc. per patient regardless of the site or cause of the obstruction. The importance of this observation is borne out by a comparison of our operative mortality in small bowel obstruction, exclusive of strangulated hernia, during two periods of three years each. During the initial period of observation, 52 patients with intestinal obstruction required surgical intervention. Of these, only one of five received whole blood before operation and the operative mortality was 19 per cent. In contrast, an average of 960 cc. of whole blood was given to three of every four patients operated upon during the subsequent period and the operative mortality in the 54 patients was only 3.7 per cent.

Antibiotics

A broad-spectrum antibiotic should be given as soon as a diagnosis has been fairly well established so as to insure a high blood level and saturation of any peritoneal exudate. Early antibiotics are particularly important when dealing with a strangulating obstruction.[14] A depository penicillin combined with streptomycin given simultaneously and repeated twice daily thereafter will help insure therapeutic blood levels.

After replacement treatment is well under way, attention is given to a more accurate diagnosis of the obstruction. If the clinical signs of shock are absent or have been controlled, one should proceed with the initial x-ray studies.

X-ray Evaluation

The x-ray diagnosis of obstruction depends upon the visualization of distended intestinal loops which are outlined by their gaseous and liquid contents. Initial studies should include flat and upright films of the abdomen and an upright film of the chest. The routine use of a coin taped in position over the umbilicus permits accurate localization of any distended large bowel, thus aiding in the differential diagnosis between small and large bowel obstruction. In turn, if an obstructed colon is found, the proper choice of incision for decompression colostomy is made possible.

Further Diagnostic Steps

It should be remembered that a clear-cut diagnosis of small bowel obstruction cannot be made unless the obstruction is complete or nearly complete. If the initial findings are inconclusive, the studies should be repeated at short intervals (four to six hours). In addition, the site of obstruction must be sufficiently low that the patient cannot completely empty the proximal bowel by vomiting. In this instance, the diagnosis depends on the patient's story and physical findings. If large bowel obstruction is suspected but not satisfactorily proved, a sigmoidoscopy may prove helpful since nine out of ten obstructions of the large bowel occur in the left colon. Failure to demonstrate the obstructing lesion is sufficient reason for an emergency barium enema.

The Operation

Timing

With the diagnosis in hand and when maximum response has been attained, one should proceed with operation. It should be remembered that an elevated pulse rate that fails to respond or increases, might well indicate inadequate fluid or salt replacement; however, incipient or actual gangrene must be ruled out. In these instances, abdominal paracentesis using an 18 gauge needle for aspiration may be diagnostic, since bloody peritoneal fluid invariably means the presence of strangulated bowel[12, 13] and constitutes a definite indication for immediate operation. If the peritoneal fluid is clear, fluid and salt intake is increased. After the estimated requirements have been supplied, including 500 cc. of whole blood, operation is carried out forthwith.

Anesthesia

Spinal anesthesia, which was employed in approximately one-half of the total patients reviewed, resulted in satisfactory relaxation in the majority; and since pulmonary and other complications have been minimal, its continued use is recommended.[11] Induction with Pentothal Sodium followed by in-

halation anesthesia using cyclopropane and oxygen has proved satisfactory in the occasional acutely ill patient who, having failed to respond despite adequate preparation, is of necessity brought to operation in a borderline state of shock. The fatal asphyxia which sometimes accompanied the use of spinal anesthesia in such patients has thus been avoided.

Choice of Incision

The incision is placed over the suspected site of obstruction. Factors to be considered include the demonstration of a point of maximum tenderness, the finding of a palpable mass and the presence of an abdominal scar from a previous operation, especially if it is tender at the time of laparotomy. In the latter instance, the incision is made to one side of the scar since the site of obstruction may be near this point. If the exact location of the obstructive lesion is in doubt, a right paramedian incision with two-thirds of its length below the umbilicus is preferred since the lower ilium is most frequently involved in small bowel obstruction.

Technical Points

On opening the abdominal cavity, the surgeon notes the amount and characteristics of the peritoneal fluid, remembering that bloody fluid indicates an impaired blood supply. A specimen of the contained fluid is taken for bacteriologic investigation including sensitivity studies of the organisms present. If the site of obstruction is obscured by ballooning-up of the markedly distended bowel, a decompressive enterostomy should be considered.[16] Preliminary evacuation of gas and fluid is accomplished with an 18 gauge needle attached to a suction apparatus or to a Luer-Lok syringe equipped with a two-way stopcock permitting hand aspiration. If further decompression is desired, enterostomy clamps are applied on either side of the needle and a purse-string suture is placed about the aspiration site; the needle is then removed and may be replaced with a long No. 18 F. catheter with minimal contamination. Gentle elevation or tilting of the intestine will cause the fluid contents to run in the direction of the advancing catheter. The use of intermittent suction obviates plugging of

the holes in the catheter by intestinal mucosa. As the distended loops of bowel are emptied, they are reefed gently upon the catheter permitting emptying of more proximal segments. If a postoperative enterostomy is thought advisable as a safety valve, a second purse-string suture is placed about the catheter and pulled snug, thus fixing the catheter to the bowel wall. The proximal end of the catheter is brought out through a stab wound in the abdominal wall. Relief of distention afforded by enterostomy minimizes the danger of accidentally opening the bowel while attempting to free dense band adhesions.

When blood supply has been impaired, viability must be determined. Absence of arterial pulsations along the mesenteric border and failure of peristalsis to progress over the questionable area are generally considered reliable signs of nonviability. The final decision, however, is not made for as long as twenty to thirty minutes after relieving the obstruction. During this interval, the inhalation of 100 per cent oxygen may be helpful. Five to 10 cc. of 1 per cent procaine is injected into the adjacent mesentery and the questionable bowel is placed in warm saline packs or returned to the abdominal cavity. The latter maneuver serves to minimize any stretch on the mesenteric vessels. Resection followed by an end-to-end anastomosis is indicated if the viability is still questioned at the end of the waiting period.

Before closing the wound, the surgeon must examine the entire small bowel, section by section, from the ligament of Treitz to the ileocecal valve, to be certain that no secondary lesion or cause of obstruction exists.

Summary and Conclusions

Four hundred and fifty-four consecutive cases of small bowel obstruction seen in the past ten years have been reviewed and the effectiveness of treatment evaluated. A statistically significant improvement in the percentage of successful results has been realized during recent years. The incidence of gangrene fell to only one in ten cases, and the overall operative mortality approximated 4 per cent.

During this period intestinal intubation was abandoned in favor of gastric suction, vigorous fluid, electrolyte, and whole blood replacement and, finally, early operation. Although a

number of factors are undoubtedly concerned, including the availability of the newer chemotherapeutic and antibiotic agents, the improvement in the end results is best ascribed to earlier operation.

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Use of the Long Intestinal Decompression Tube in the Management of Small Bowel Obstruction

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No one method of treatment can be successful in the management of all cases of small bowel obstruction. Each case must be individually evaluated and the treatment must also be individualized. A patient with early intestinal obstruction, who is not distended, whose nutrition is good and is in normal electrolyte balance, is expected to recover with prompt surgical treatment. However, patients seen late in the course of the disease constitute a major abdominal catastrophe. In these persons there are many facets to the problem, each of which must be treated. Intestinal distention, dehydration, electrolyte imbalance, and bacterial invasion are individual problems requiring proper correction.

The True Role of the Tube

We must constantly bear in mind that the intestinal decompression tube is not, in itself, a treatment for intestinal obstruction. This tube is simply an instrument to treat one facet of bowel obstruction—namely, intestinal distention. This and this alone is the function of the long intestinal decompression tube. In acute small bowel obstruction due to adhesive bands, the use of the long intestinal decompression tube may result in a successful resolution of the acute obstruction. The obstructing bands, however, remain. They may again cause obstruction at a later date.

Intestinal intubation and decompression of the gastroin-

testinal tract must not be a substitute for surgery. Although such intubation and decompression may be the sole method of treatment for the nonmechanical types of ileus, it is only an adjunct to the surgical treatment of mechanical small bowel obstruction. All types of acute mechanical bowel obstruction must be considered in this fashion. Attempts to classify such mechanical obstructions as strangulating or nonstrangulating, for the purpose of using the tube as a sole method of treatment in the nonstrangulating type, is dangerous. It has been amply demonstrated that, although most cases of small bowel obstruction can be reasonably diagnosed as strangulating or nonstrangulating, in an appreciable number of cases such an exact diagnosis cannot be made. Many obstructions considered by all criteria to be nonstrangulating were found at operation to be strangulating.

We cannot deny that the long intestinal decompression tube is of great value when properly used, and may even be a life-saving instrument. The indiscriminate or prolonged use of this tube can have harmful effects. The waste of time, in a futile attempt to secure successful intubation, may make the difference between success or failure in treatment. Experience has shown that the surgeon who uses the long intestinal decompression tube as a substitute for operation assumes a far greater responsibility than the surgeon who insists upon operation in all cases of suspected intestinal obstruction. The best course is to use the intestinal decompression tube as an adjunct to treatment but not as a method of treatment per se.

Diagnosis of Intestinal Obstruction

Intestinal obstruction is an abdominal catastrophe which may be easily diagnosed or may be so insidious that it taxes the diagnostic ability and surgical judgment of even the most experienced surgeon Small bowel obstruction can be caused by a wide variety of pathologic entities which ultimately produce the same end results. Although an exact diagnosis of the obstructing mechanism is possible in many cases, such as incarcerated hernia, intussusception, and small bowel tumors, there are a great many cases in which such an exact etiological diagnosis is not possible. The best that one can hope for in such patients is a diagnosis of acute intestinal obstruction. It is of

greater importance to know whether an obstruction is complete or incomplete, strangulating or nonstrangulating, than it is to know the exact pathologic diagnosis.

Incomplete nonstrangulating obstructions (even of high grade) accompanied by intestinal distention, permit the surgeon adequate time to study the problem to make a more exact diagnosis. During this period of study, intestinal decompression by the long tube, adequate hydration, and correction of electrolyte imbalance and anemia may be carried out. This puts the patient in the best possible condition for operation, if one is required.

The Recognition of Strangulation

The most serious error in the management of small bowel obstruction is *the failure to recognize the presence of a strangulating obstruction.* Unfortunately, one cannot be certain in all cases that a strangulating type of obstruction is not present. One cannot depend too much upon a classic history or the pathognomonic findings commonly associated with strangulating obstruction—severe abdominal pain, shock, leukocytosis, and abdominal tenderness. In many instances, before the above classic findings appear the patient will be beyond human help. In some instances, none of the so-called signs of strangulation is found despite careful examination. Since this is so, all cases of mechanical obstruction must be considered as potentially strangulating and carefully observed for proof or disproof. The frank cases of strangulation do not constitute a problem since proper surgical management is given at once. The borderline cases or those diagnosed as "simple" obstructions constitute a real problem since some of these are really strangulating from the beginning and others become so with the passage of time. Here surgical judgment and experience are of the greatest importance.

Indications for Use of the Long Intestinal Decompression Tube

Small bowel disorders requiring intestinal intubation may be divided into three main groups:

1. All cases of *ileus due to atony* of the bowel. In this group, the distention cannot be attributed to mechanical or vascular mechanisms

2. All cases of intestinal distention resulting from *inflammatory intra-abdominal processes.*
3 All cases of *ileus due to mechanical lesions* regardless of cause

Atonic Ileus

There are many and varied mechanisms capable of producing intestinal distention on a nonmechanical basis. Surgical trauma is a common cause of this type of ileus. Peritonitis, either local or diffuse, is usually accompanied by a progressively increasing intestinal distention in which the small bowel is filled with fluid, gas and particulate matter. Retroperitoneal lesions are common sources of ileus. In such cases, the intestinal distention may be severe and must be adequately treated. Among these retroperitoneal lesions are: aneurysm of the abdominal aorta, diseases of the kidney, ureter, and bladder, retroperitoneal tumors, and a wide variety of lesions retroperitoneal in origin. In the aged, intestinal atony may occur with any type of infection or trauma.

In all patients in this group, the intestinal decompression tube may be used as a sole method of treatment for the intestinal distention. However, a correct diagnosis of the inciting process must be made and treatment to eliminate it is essential. The use of the intestinal tube corrects one facet of the process and allows time to diagnose the cause of the ileus and remove it.

Inflammatory Distention

Patients in this group present one thing in common. This is an inflammatory process within the peritoneal cavity. This may be the result of generalized peritonitis, local peritonitis, or an abscess anywhere within the abdomen.

Localized peritonitis or intra-abdominal abscess constitutes an individual problem. In such cases, two types of ileus may be present—a reflex paralytic ileus due to peritoneal infection, or a mechanical obstruction caused by adherence of a loop of bowel to the inflammatory mass. The resultant edema in the bowel wall or kinking of a loop so adherent may cause mechanical obstruction.

In this group, the long intestinal decompression tube passed far down the gastrointestinal tract keeps the small bowel

decompressed and by so doing creates an opportunity for the edema to subside, thus releasing the obstruction. If the obstruction is solely functional in origin, gas and liquid stools are generally passed per rectum by the fifth day. An effort should be made to permit the inflammatory process to subside with conservative measures. A waiting period of ten days is not too long provided the temperature decreases, the white blood count returns to normal, intestinal decompression is maintained, and the patient shows clinical improvement. During this period of time, intravenous fluids are given and a high caloric liquid diet may be given by mouth. With the long tube well down the ileum, some utilization of the ingested material will take place.

Before the long tube is removed from any patient in this group, it must be established that the patient is not mechanically obstructed. This information may be obtained in two ways:

1. A small amount of dilute barium (200 cc.) may be injected through the tube and its downward course checked radiologically. If the barium is shown to pass into the colon without producing puddling in the small bowel, the continuity of the small bowel is established.
2. Passage of gas or stool by the patient after the tube has been clamped off is presumptive evidence of patency of the gastrointestinal tract. It does not, however, rule out the presence of partial intestinal obstruction.

Mechanical Intestinal Obstruction

All patients in this group present a mechanical interference with the passage of intestinal contents from os orum to os anum. This may be due to obstruction of the bowel from within its lumen, from its wall, from outside the lumen, or as a result of interference with the circulation to the bowel. The pathology varies from adhesive bands to mesenteric thrombosis.

The use of the long intestinal decompression tube in such cases should be reserved *for only those patients who are distended.* In patients with early intestinal obstruction and in those with high jejunal obstruction, in whom distention is not a problem, early surgical intervention with or without an intestinal tube is the procedure of choice. The function of the long intestinal tube is simply to carry the patient over the period of

emergency, thus giving the surgeon time to decompress the bowel, permit adequate preoperative preparation and adequately prepare the operative field. Too much time must not be taken to accomplish this objective since it is impossible to be certain in all cases that the mechanical obstruction is not strangulating in type. This is a most serious error.

The permissible time interval between the passage of the long tube and surgical intervention is variable. It may be as short as six hours or as long as twenty-four hours, and in an occasional instance forty-eight hours. The course of the long tube and the progress of the intestinal distention is followed by x-rays every four hours. If the tube is progressing satisfactorily and the distention is decreasing radiologically and clinically at the end of six hours, a second six-hour period is permitted. Again, the clinical and radiological improvement is a guide to further management. Any change for the worse or any suggestion of strangulation is an indication for immediate surgical correction. If intubation is successful in completely decompressing the bowel proximal to the point of obstruction within twenty-four hours, there has been adequate time to hydrate the patient, correct electrolyte imbalance or anemia, and give ample antibiotic. Surgical intervention now becomes simple and safe.

Intestinal intubation may result in complete decompression of the bowel mechanically obstructed by adhesive bands. Gas may be passed per rectum and the bowels may move. There is a tendency to discharge such patients as cured by intubation alone. Reports from many centers, as well as our own experience, reveal the startling fact that between 25 and 30 per cent of these patients return within one year with a second complete obstruction. For this reason, such patients should not be discharged until barium has been injected through the tube and followed to determine the patency of the distal bowel. Any puddling of the barium is indicative of the point of obstruction which should be surgically corrected.

Exceptions to This Course of Action

The exceptions to the above course of action are few but easily recognizable. These are:

1. In patients presenting extensive matting of the small

bowel from multiple operations for intestinal obstruction, ir tubation may carry the patient over the acute process. Late those patients in whom less than 40 per cent of the small bowe is so matted may require resection of the damaged bowel an primary end-to-end anastomosis. The patients in whom mor than 40 per cent of the small bowel is matted may require Noble plication procedure.

2. A patient, in whom we are reasonably certain that th obstruction is due to adhesions and in whom x-ray studies show successful decompression (Figs. 1–4), may be treated conserva tively. If the clinical course shows progressive improvemen and thin barium injected via tube fails to reveal a point of ob struction, treatment by tube alone is considered successfu However, the patient must be instructed to seek a surgeon a once if the abdominal pain recurs.

3. The tube alone may be used in an occasional patien in poor condition and markedly distended as a result of radio paque gallstone ileus. Successful intubation in such patient



Fig. 1. Note small bowel loops distended with gas. No gas in colon Diagnosis: acute small bowel obstruction (adhesions).



Fig 2. Small barium swallow. Note contrast medium showing small bowel distention. Film taken immediately after that of Figure 1.

may result in the spontaneous excretion of the gallstone in 25 per cent of the cases. Repeated x-rays and careful clinical observation are permissible as long as improvement is satisfactory. Immediate surgery in an improved patient may be required at any time. Except in such patients in poor condition and markedly distended, generally immediate surgical intervention is indicated if a correct diagnosis is made.

4. On two occasions in the past twenty years, the long tube was used successfully to treat two aged patients in very precarious condition. One developed mesenteric thrombosis which infarcted a small segment of bowel during the course of a severe coronary attack and the second patient developed a similar process during the acute phase of cerebral hemorrhage with hemiplegia. Both of these patients presented impossible surgical risks. Treatment consisted in successful intestinal intubation, massive antibiotic therapy (1,000,000 units of penicillin every three hours) and adequate hydration. In both in-



Fig. 3. Successful intubation with Cantor tube. Film taken 48 hours after that of Figure 1. Dilute barium injected via tube.

stances, the patients recovered only to develop stenosis at the point of infarction within the following two years. This was successfully resected. Such cases rarely occur, but when they do and the patient's condition does not permit operation and the section of bowel infarcted is not long, an otherwise hopeless case may be salvaged.

Summary and Conclusions

In treatment of small bowel obstruction, the question is not whether to use a long intestinal decompression or a gastroduodenal tube. The question is really whether to operate upon the patient at once or whether to treat the intestinal distention before operation. Since the intestinal decompression tube is simply an instrument to treat intestinal distention, it must be apparent that those patients with mechanical small bowel obstruction who are not distended should be treated surgically



Fig. 4. Five-hour film after injection of dilute barium. No point of obstruction demonstrated. Cantor tube removed.

without preliminary use of the tube. On the other hand, those mechanically obstructed patients who are distended may be treated for a reasonable period of time with a tube prior to operation.

As to the choice of tube, certain generalizations are possible. If the intestinal content is chiefly gas, such as is found in early obstruction due to swallowed air, then a short gastroduodenal tube would be efficient as a decompressing instrument. However, since the distention in most cases of intestinal obstruction consists of gas, fluid, and intestinal particulate matter, the law of diffusion of gases does not apply as it would if the distention were only gas. Therefore, before the short gastroduodenal tube could effectively decompress distention of this type, a reversal of the intestinal stream would have to occur so that the intestinal contents could reflux into the stomach or duodenum where the tube lay. This is not only inefficient but it violates our primary objective—namely, to restore normal

peristalsis with the passage of intestinal contents from mouth to anus. A long intestinal decompression tube, on the other hand, when successfully passed to the point of obstruction produces decompression of the entire proximal bowel and removes all gas as well as fluid and intestinal particulate matter from the lower reaches of the small bowel. The proximal bowel, being decompressed, regains its tonus.

At operation it is simple to correct the mechanical obstruction since the bowel proximal to the tube head, which lies at the point of obstruction, is decompressed. The surgeon needs simply to pick up a loop of bowel containing the tube and follow it distally to its head end.

All cases of nonmechanical intestinal stasis such as paralytic ileus may be treated solely by the long tube to correct the distention. This done, then proper hydration, electrolyte correction, antibiotic therapy and removal of the inciting factor result in a cure.

In the inflammatory distention group, the long tube may be used without operation if the other facets of the problem are corrected. The obstructing process may resolve spontaneously. However, one must be eternally vigilant in these cases because a certain number will require surgical correction.

Finally, the long intestinal decompression tube can effectively do everything that the short gastroduodenal tube can do, and can in addition decompress the lower reaches of the small bowel which a short gastroduodenal tube cannot do. It would appear that we have everything to gain by using a long tube and nothing to lose. In well over 90 per cent of the cases, the long tube can successfully be passed into the small bowel if careful attention is given to detail. In those few instances in which the long tube cannot be successfully passed into the lower small bowel it may remain in the stomach, and here it functions better than the gastroduodenal tube because of the multiplicity of holes for decompression. The nose, nasopharynx, esophagus, and stomach of the patient cannot distinguish between a long intestinal tube and a short gastroduodenal tube. Both are somewhat uncomfortable and both give rise to the same possible complications incident to their use. Since these patients are very sick people in whom intestinal intubation is of great value, the slight risk incident to intubation must be

accepted. Proper attention to detail will reduce such complications to a negligible minimum.

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Management of Arterial Insufficiency of the Lower Extremities

Introduction

The management of arterial insufficiency of the lower extremities resulting from arteriosclerosis has challenged the judgment of physicians and the technical skill of surgeons since Harvey first emphasized the difficulty of transmission of the pulse in the thickened calcareous arteries so characteristic of this disease entity. With few exceptions, the disease and in turn the symptomatology are progressive without treatment, ranging from calf pain on exertion (intermittent claudication), which may in itself prove to be incapacitating, to the continuous intolerable rest pain of ischemic neuropathy. Hypesthesia and hyperesthesia precede and/or accompany ulceration and gangrene of the digits, heels and ankles and, in the more unfortunate, atrophy and deformity of disuse, infection or an extensive gangrene precludes all therapy except amputation. Although in recent years new and exciting attacks have been made on this common and disabling disease, the methods of approach differ widely and there is little or no agreement as to the preferred method(s).

Much of the controversy results from differences of opinion as to whether the arteriosclerosis may be localized to one segment of a single vessel or is always a generalized process, and as to the relative importance of the arterial occlusion and the associated arterial spasm. Those favoring generalized involvement stress a more conservative approach including non-operative management. Eradication or bypass of the obstructive lesion is thought advisable if localized disease is suspected, and prophylactic or adjunctive sympathectomy is favored by those

concerned with associated vascular spasm. Although the value of methods designed to stimulate development or improve the efficiency of the collateral vessels is frequently debated, the importance of collateral circulation in preventing the more serious complications is generally recognized. In turn, endarterectomy or some type of bypass procedure (depending on the location and extent of the obstruction) with preservation of existing collaterals is preferred by some to that of excision and restoration of continuity by a replacement graft. Finally, although the peripheral vascular shunt is proving to be very popular, there is no general agreement as to what type of graft should be employed. Arterial homografts, autogenous vein grafts, and a variety of synthetic prosthetic grafts have been and are being evaluated and a final decision is not yet possible.

The arguments for and against each method or combinations thereof are well presented in the following section. When evaluating the results, however, the reader should realize that failure of an operative procedure per se is difficult to differentiate from progress of the disease. Finally, one wonders if a combination of a well chosen and well executed operation with the principles of nonoperative management might not result in a greater number of satisfied patients with useful, pain-free limbs.

E. H. E.

The Conservative Management of Arterial Insufficiency of the Lower Extremities

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Arterial insufficiency in human extremities may result from several different pathologicophysiologic mechanisms, so indications for treatment may be varied. Severe trauma to extremities, active inflammation of arteries (nonspecific arteritis), degenerative changes in peripheral arteries (arteriosclerosis obliterans), and the idiopathic vasospasm of Raynaud may seriously impair the efficiency of peripheral arterial circulation and produce local death of tissue of the distal parts of the feet.

The Basis for Practical Therapy

It is fair to assume that all arterial insufficiency in human extremities must result either from arterial spasm, arterial occlusion, or some combination of these two conditions. At the present time our therapeutic efforts should be directed toward the amelioration of the signs and symptoms, rather than toward any primary attempt to eradicate the underlying pathologic process. Active treatment of these disturbances should consist of the constant and efficient utilization of all the general, medicinal, and surgical measures which experience has shown to be of definite value in overcoming peripheral vasospasm, improving peripheral circulatory balance, and preventing infection from gaining entrance into the poorly nourished tissues of such an extremity.

Some Disadvantages of an Aggressive Surgical Attack

Great strides have been made during the past two decades relative to efficient supportive treatment of seriously ill or in-

jured persons. Safer and better anesthesia, the abundant supply of banked blood and blood substitutes, and the specific means of combating bacterial infections have had their influence in triggering an aggressive surgical attack upon obliterated major and secondary arteries in human extremities. Many of the more enthusiastic advocates of primary surgical treatment have placed great emphasis upon the so-called "segmental lesions" of atherosclerosis and have not given sufficient thought to the undisputed fact that peripheral arteriosclerosis obliterans is only part of a progressive systemic disturbance which variously affects all arteries of the body.

The *exclusive use of this radical form of surgical* treatment of obliterated peripheral arteries unfortunately has resulted in the abandonment of many of the important and fundamental concepts of therapy of arterial insufficiency in such extremities. The desire to free these patients from the rigid regimen of meticulous hygiene of the feet, from alterations in their personal habits, or from the need for a total change in their way of living has prompted many unwary surgeons to commit the sin of performing unnecessary or ineffective surgical operations and thus become unintentional promulgators of false hope. As a result of this wave of enthusiasm for immediate symptomatic relief by surgical intervention, physicians and surgeons alike have neglected to employ those *conservative therapeutic measures* which experience has shown are often the deciding factors between temporary benefits and long-term relief of symptoms without further serious complications.

The Importance of Maintaining an Adequate Collateral Arterial Circulation

It is important in this discussion to distinguish sharply between palliative or temporary benefits, and curative or definitive measures. The fact has been established that the human body often develops spontaneously in diseased extremities an abundant collateral arterial circulation, especially in those people who, because of slowly progressive arteriosclerosis obliterans, develop the occlusion of major peripheral arteries over a period of many months or years. It becomes difficult, therefore, to predict without a careful and prolonged clinical study which of the patients with obliteration of peripheral arteries will con-

tinue to improve with conservative treatment alone and which of them will get worse, or to assess the true value of our therapeutic measures in any given patient.

Physicians and surgeons interested in geriatrics have a unique opportunity to demonstrate clinically the importance of the collateral arterial circulation in maintaining viability of tissues in limbs of patients with advanced obliterative arterial disease. Routine palpation of the peripheral pulse has revealed that many middle-aged and elderly patients have viable extremities despite the absence of palpable pulsations distal to the femoral artery, or even beyond the bifurcation of the aorta. This observation is of basic significance because it emphasizes an aspect frequently overlooked in the description of the pathologic physiology of this disease and demonstrates the ability of the human body to compensate for progressive arteriosclerosis obliterans of peripheral arteries.

Observations are rapidly accumulating which seem to justify the belief that the vast majority of the serious complications of peripheral arterial insufficiency result from a speeding up of the usually slow progressive occlusion of arteries, or from an insult through trauma, infection, or cold, which throws not only an acute burden on the collateral arteries but induces a period of peripheral arterial spasm. This more or less acute demand on the collateral arterial circulation with associated vasospasm of varying intensity gives rise to severe ischemic pain and local death of tissue unless the patient or the doctor, or both, can do something to tide such patients through these critical phases of arterial insufficiency. A typical example is the cadaveric, vasospastic extremity resulting from the sudden occlusion of a large artery by an embolus or from severe injury of the soft tissues of that part of the body. The same process is repeated with varying clinical manifestations when the occlusion is only relatively rapid as a result of thrombosis of diseased arteries. A series of such events is witnessed repeatedly in patients with thromboangiitis obliterans.

From what has been said, it is obvious that the great opportunity in this field rests in the early recognition of peripheral arterial insufficiency. We should make a determined effort to study the peripheral arterial circulation more carefully and then advise the patient when there exists a thin margin of safety in the blood supply of an extremity, for there are many

things which can be done to avoid those complications which cause critical periods of pain, infection, and local death of tissue.

General Measures of Therapeutic Value

Enlisting the Active Cooperation of the Patient

In clinical practice, it is difficult to make most patients realize the importance of the many precautions which must be observed, and even still more difficult to have them respond in an intelligent manner. Bitter experience has taught us that the fault frequently rests with the doctor because he has not taken time, nor has he had the patience, to explain in detail the basic reasons for such a regimen. Most patients readily understand that a reduction in the arterial circulation means definite impairment of the nutrition to the tissues, and that the many things which have been outlined to them with respect to the position and exercise of the extremities, the avoidance of cold, the hygiene of the skin, and general protection from all forms of trauma are in reality efforts to keep the nourishment of the tissues of the extremities at a maximum level to enable them to combat infection in a normal manner. Any abrasion or minor infection around the base of the nail, between the digits, or anywhere on the distal portions of the extremities should be given extraordinarily good care, and inflamed areas in the region of any of the peripheral vessels should not be traumatized in any way.

A short period of hospitalization for the express purpose of teaching the patient how to care for his extremities and how to carry out accurately the valuable exercises proposed by Buerger and Allen is highly desirable.

Care of the Skin of the Extremities

Arterial circulation is unquestionably better when the skin is soft and delicate, thus allowing the freest exchange of nourishment between the circulating blood and the tissues. Soft and smooth skin also reduces to a minimum the dangers of infection. Cracks and calluses always are associated with thickened skin which is nonpliable and binding. Careful cleansing of the skin with neutral soap (Ivory), followed by an application of lanolin (Nivea Cream), should be carried out frequently

each day until the skin becomes soft and pliable. Corns and calluses should receive proper care by some experienced person, such as a chiropodist. It is gratifying to see how much enthusiasm the patient will show over the results he obtains from such care of his skin after he fully understands the importance of such care and obtains proper recognition for his efforts.

Prevention of Trauma

The vast majority of the serious complications of peripheral vascular disorders occur during cold weather. It is extremely important, therefore, that we institute treatment or suggest a mode of living which will minimize to the greatest extent the harmful effects of cold. The patient's subjective appreciation of warmth and cold is most untrustworthy and we should never accept his assertion that his feet are warm. When a patient of this type thinks that his feet feel warm, it is well to have him feel for himself that they are objectively cold. Such patients should constantly wear woolen socks with or without fleece-lined shoes, in order that the feet can be kept warm and made to perspire most of the day.

Unfortunately, a great majority of the people past middle life are not cognizant of the danger of arterial insufficiency of their extremities and usually do not seek treatment for a trivial wound, blister, infection, or discoloration of the skin until it has progressed to a dangerous stage or until local death of tissue has occurred.

Abstinence from Use of Tobacco

The clinical experiences of Silbert, Buerger, Samuels, and others, and the experimental studies of Sulzberger, Harkavey, Coller, and Maddock have demonstrated quite conclusively the harmful effects of tobacco. Marked peripheral vasoconstriction which results from the use of tobacco increases the deficiency of the arterial circulation in patients with the degenerative types of arterial disease and definitely aggravates the process in patients with true thromboangiitis obliterans and Raynaud's syndrome. In the treatment of arterial insufficiency in extremities, the use of tobacco in any form must be prohibited.

Optimum Resting Level

The position of the resting extremity which affords the best exchange of arterial and venous blood should be determined during the first examination of any patient showing objective evidence of a peripheral circulatory disturbance. The many degrees of peripheral vascular deficiency make it obvious that this level of optimum circulation must be independently determined for each patient, and usually at various times during the course of active treatment.

When the extremity of a patient with extensive organic disease of the peripheral arteries and arterioles is placed in the dependent position, the foot usually becomes purplish-red in color and the superficial veins become greatly distended. The efficiency of the circulation in such an extremity is greatly reduced and the nutrition impaired, because of the marked increase in the venous pressure which causes stagnation of the blood in the capillaries and the venules.

If, on the other hand, the extremity is elevated above the level of the heart, the foot usually becomes cadaveric in color and the superficial veins empty quickly and appear as grooves in the skin. The force within the organically diseased arteries usually is insufficient to carry the oxygenated blood to the distal portions of the extremity; consequently, the tissues are again deprived of adequate nourishment. The tissues receive the greatest nourishment at the level where the superficial veins are visible and filled to the extent that they project slightly above the level of the skin. Ordinarily this position is between 3 and 6 inches *below* the level of the heart.

It has been our experience that patients show a great deal of interest in making these observations and, after they have been made to realize the importance of this position, they usually endeavor to place the affected extremity at the determined level of optimum circulation whenever they are at rest.

Active Graded Exercises

The improvement in the circulation which can be brought about by graded amounts of active exercise, whenever infection and gangrene are not present, is not difficult to demonstrate to the patient. Active movement of the ankle and toes

usually will bring about a striking improvement in the color of an affected foot. We usually ask our patients to stand for a few minutes and then observe for themselves the improvement which follows active exercise of the toes and ankles. The subjective sensation of tingling or tightness in the feet, due to congestion, usually disappears quickly after such active exercise. As soon as the cooperative patient learns that these subjective sensations can be relieved, he frequently will resort to this simple means of altering the peripheral circulation. At this point, it is wise to explain carefully the harm which might result from too much exercise, as well as the meaning of the pains of intermittent claudication.

Control of Factors Causing Complications

What, then, can the physician do to aid the natural process of maintaining adequate arterial circulation against the threat of ischemic necrosis in extremities? Logically, there are two approaches which can be pursued concurrently. The *first* is to reduce the requirement for blood and to eliminate the factors that reduce effective arterial circulation. The *second* is to increase the amount of blood reaching the distal parts of these extremities.

Local Heat

Foremost among the conservative measures for reducing excessive demand for blood is avoidance of local heat. Since heat is the physiologic stimulus for the relaxation of the arterioles, it was not unreasonable that practicing physicians often applied it to ischemic limbs in expectation of increasing arterial circulation. The fallacy of this was emphasized by Starr in 1934 and Freeman in 1940. Local heat increases metabolism and therefore creates a demand for blood beyond the capacity of the obstructed arteries to supply it. In addition, the tissues burn more easily because the impaired circulation cannot dissipate the heat effectively. Finally, sensory acuity frequently is diminished in patients with arterial insufficiency of the extremities, so that the patient is unaware that his skin is being burned. To re-emphasize, the local application of heat to a limb with arterial insufficiency due to obliterative arterial

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the efficacy of the various methods of producing vasodilatation. Much of this confusion comes from failure to recognize three fundamental facts: (1) Normally, there is a greater degree of vasomotor tone in the lower than in the upper extremities or face; therefore, vasodilatation in upper portions of the body should not be used as a criterion of effectiveness of an agent expected to be useful in promoting vasodilatation in the lower extremities. (2) The difficulty in producing vasodilatation in the normal lower extremities is magnified many times by the presence of obliterative arterial changes, so that many agents which can produce vasodilatation in the normal lower extremities lose their effectiveness in the extremity with obliterative arterial disease. (3) The variations in the extent of the arterial involvement always must be considered. An agent that will produce vasodilatation in an extremity with minimal arterial obstruction may be valueless in an extremity with moderate or advanced obliterative vascular disease.

Chemical Vasodilators

Our studies indicate that many orally administered vasodilating drugs fail to cause a significant degree of peripheral vasodilatation even in the normal lower extremity and, therefore, cannot be expected to have an appreciable effect on patients with structural changes in the arteries. These include papaverine, nicotinic acid (niacin), pancreatic extracts, calcium gluconate, thiamine chloride, dioxyline phosphate, and Roniacol tartrate. Alcohol, Arlidin, Ilidar, and the tetraethylammonium and hexamethonium ions produce vasodilatation in the normal lower extremity, but their peripheral vasodilating effect is not constant or is minimal in the lower extremities of many of the patients with obliterative arterial disease. These drugs should be given a reasonable clinical trial, however, for the benefits, actual or psychological, occasionally are of considerable magnitude.

Metabolites

Insufficient attention has been given to vasodilator effects of the metabolites. These substances are continually being produced in the distal part of an extremity, though in smaller

changes is one of the most effective means of *precipitating* gangrene.

Infection

Infection increases the requirement of the tissues for oxygen; hence, it must always be given serious consideration in extremities with obliterative arterial disease. Scrupulous foot hygiene pays big dividends in preventing local sepsis. When infection is present, the sensitivity of organisms cultured from exudates of the wounds should be tested against the various antibiotic substances, in order to determine the most potent therapeutic weapon. The dose of the antibiotic agent should be larger than that usually employed, because of the local ischemia of the tissues in these patients. The value of bed rest in treatment of infections in extremities with obliterative arterial disease cannot be overestimated; but, as a matter of fact, it is frequently grossly underrated.

Exposure to Cold

Freezing cold is injurious to a normal limb, and even moderate cold can cause vasoconstriction in a limb with obliterative arterial disease. Cold causes vasoconstriction reflexly through the autonomic nervous system and, in addition, has a direct vasoconstricting effect on the arterioles themselves. Therefore, the limb with obliterative arterial disease should be protected from cold at all times.

Methods of Producing Vasodilatation

Dilatation of the arterioles of an extremity reduces significantly the resistance to the flow of arterial blood to the part, so the reduction of peripheral resistance has centered about the methods of producing peripheral vasodilatation. Vasodilatation may be produced by physiologic stimulus (warmth), by chemical means (vasodilator drugs), by novocainization of the regional sympathetic ganglia or peripheral somatic nerves, or by the surgical extirpation of the regional sympathetic ganglia of the affected parts.

The literature is replete with conflicting evidence as to

the nerves in the vessel walls. These nerves are thought to be stimulated by the various metabolites, and then, through a local reflex, can cause peripheral arterial dilatation.

Value of Collateral Arterial Pathways

The limb with major arterial obliteration and a fully developed collateral arterial circulation has passed the crisis and usually is safe from the danger of massive ischemic necrosis, barring severe trauma or infection. This is the basis for the hallowed clinical observation that a viable limb without a palpable pulse in the larger arteries at the ankle and knee is less apt to show gangrenous changes than the other limb in which the pulse is readily palpable at these sites.

This suggests strongly that primary therapeutic emphasis should be on the *collateral arterial circulation.* It is true that occasionally some extremities will show an apparent solitary obstruction in an otherwise patent major arterial tree. In such instances, excision of the obliterated segment with re-establishment of arterial continuity through implantation of a synthetic or, preferably, venous graft is indicated. In our experience, the number of patients in whom such a sole segmental obstruction can be demonstrated represents an extremely small fraction of the total number who seek relief of symptoms from arterial insufficiency due to obliterative arterial disease. The diffuseness of the obliterative process, the tendency for recurrent arterial thrombosis, and the efficiency of the collateral arterial circulation after it becomes fully developed, force one to the conclusion that maximum benefit to the largest number of patients will be obtained by directing primary therapeutic aims toward the enhancement of the *collateral arterial circulation* in the affected extremity.

Enhancing Collateral Arterial Circulation

The exact physiologic stimulus for improving the efficiency of the existing collateral circulation is not completely understood. One group of investigators teaches that the ultimate stimulus is chemical in nature, due to accumulation of metabolites in the tissues; another, that all changes in the arterial circulation are best explained on a purely physical

amounts by the resting tissues; however, when the blood supply to the part is stopped for a time, they accumulate. If this blood is readmitted to the tissue, its vessels dilate widely and the result is called *reactive hyperemia.* The great increase in flow through the muscles of the extremities which accompanies muscular exercise (active vascular exercises) is probably brought about largely by similar means.

The exact nature of the metabolites concerned is still uncertain. Lactic acid and carbon dioxide cause some dilatation of the blood vessels of a limb, but the vasodilatation following muscular activity is greater than could be accounted for by these substances. Several other possible metabolites have been found to exert a dilator effect on the arterioles. One of these may be acetylcholine, or some closely related substance. When a vasodilator nerve or an antidromic sensory nerve is stimulated, there is a liberation, in the area of its distribution, of acetylcholine.

Synthetic Estrogens

In 1934, when we investigated the effect of the synthetic estrogens upon the peripheral arterial circulation in experimentally produced active angiitis similar in cellular reaction to thromboangiitis obliterans, we were impressed by the degree of vasodilatation which these substances produced in the affected extremities. In the years since then, we have observed some truly striking clinical results following the intensive use of *estradiol dipropionate* in both men and women with arterial insufficiency in their extremities. We are now convinced that this substance has a distinct place in the therapy of the arterial insufficiency which is largely due to high grade peripheral vasospasm (Raynaud's syndrome).

In a large series of elderly patients with arteriolar insufficiency in the lower extremities, with cherry red coloration or dusky cyanosis of one or more toes, the intensive use of estradiol dipropionate (Ovocylin dipropionate by Ciba) in doses of 1.0 mg. intramuscularly each day for five days, then three times a week for six or eight weeks, has caused sufficient arteriolar dilatation in the toes of the majority of these patients to prevent local necrosis of tissue. The explanation, according to Fleisch, is that an ascending local reflex is effected through

normal parts of the body. True enough, this increase in rate of flow is not entirely nutritive as some of the blood is shunted from the arteries to the veins without traversing the capillaries; but the overall clinical picture appears to be one of steady improvement in nutrition of the limbs following lumbar sympathetic ganglionectomy in properly selected cases. It is highly probable, therefore, that this prolonged vasodilatation in some way favorably influences the development of the collateral arterial circulation.

Summary

In the management of arterial insufficiency due to most of the inflammatory and degenerative arterial diseases which tend to have a slowly progressive course and establish spontaneously a more or less adequate collateral arterial circulation, it is certain that the number of complications can be reduced materially by adhering strictly to all the general measures of care which have been outlined in this work. A thorough understanding of the seriousness of the problem and the amount of time necessary for such conservative management, both on the part of the patient and the doctor, is of vital importance in securing satisfactory long-term results. The problem is often regarded too lightly and patients are allowed to expose themselves to unnecessary risks, injury, or infection during the active phases of arterial insufficiency in the extremities.

The etiology of most of the organic vascular diseases is still unknown, so the process of major and secondary arterial obliteration must be considered as being slowly progressive and more or less generalized. Consequently, the stimulation of the collateral arterial circulation is more logical than attempting to remove or to bypass an apparent localized obliteration in one peripheral artery under these conditions. Surgical sympathectomy is the most effective means of producing immediate and long-lasting vasodilatation in an extremity without affecting the arterial circulation in other parts of the body.

The prevention of the serious complications of arterial insufficiency in human extremities offers a much greater challenge to the skill and ingenuity of the surgeon, and will offer him a greater degree of intellectual satisfaction, than does the surgical care of the dreaded end-result of severe arterial insufficiency in these extremities.

basis. But whatever the ultimate explanation of its production, there is scarcely any doubt that the proximate mechanisms are purely physical and are governed by the same laws that control the motion of all enclosed fluids: specifically, the head of pressure, the peripheral resistance, and the viscosity of the fluid itself. The one most thoroughly explored to date has been a method of decreasing the peripheral resistance to the flow of blood through the existing collateral arterial pathways.

Physical Means

Attempts to do this by physical methods have been tried for more than two hundred years. The most successful application of this physical principle of promoting better collateral arterial circulation has been the use of alternating negative and positive pressure about an extremity encased within a boot (passive vascular exercises) as developed by us in 1932–1933. During the period of intensive investigation in this laboratory, objective methods of evaluating peripheral arterial circulation were not available and we had to rely on clinical evidence alone to determine the efficacy of these passive vascular exercises. Some patients showed dramatic improvement far beyond that which might be expected from conservative therapy alone or from spontaneous recovery. Some did not improve following prolonged treatment of this type. In the majority of instances, unquestionable benefit was obtained, but it was difficult to attribute it solely to passive vascular exercises because general therapeutic measures were employed concurrently. Attempts are again being made to increase the efficiency of this method by enclosing a larger segment of the body, but technical difficulties have been encountered which make it difficult to predict the future of this type of physical therapy for arterial insufficiency in human extremities.

Surgical Means

Lumbar sympathetic ganglionectomy is the best of the conservative means now available for effecting a long-acting, localized peripheral vasodilatation. This vasodilatation selectively reduces the resistance to the flow of blood in the area of the body which needs it, and does not alter the vascularity of

to dilate after function in the canine aorta was amply described.

The lack of expendable human veins suitable for use in the aorta led to the use of preserved homografts in the aorta by most surgeons. However, there were some, including Julian, Lord, Shaw, Harkins, Murphy, and Dale, who reported satisfaction with autogenous vein grafts in peripheral arteries of man. Dale recently published a monograph which presents a comprehensive and fair evaluation of autogenous vein grafts. In an extensive and long clinical experience with vein grafts in peripheral arteries, he has seen aneurysmal dilatation develop only rarely. The percentage of patent grafts reported in American series and by German and French authors, however, indicates no greater incidence of continued patency when autogenous vein grafts were used to replace or bypass occluded arteries, than has been recorded with homografts or synthetic prostheses. Rather, the results might even appear to be inferior when compared with those being reported with the newest synthetic prostheses. The unmatched diameters noted when reversing the direction of long vein grafts to avoid valvular obstruction to blood flow, and the additional operating time required to ligate all small branches of the graft have reduced some of the enthusiasm evident in the literature only a few years ago. Nevertheless, for use in small defects such as those associated with trauma or minimal aneurysms of peripheral arteries, and particularly in areas of acute flexion, the vein graft may still be considered quite satisfactory. Its unsuitability in many other areas cannot be overlooked, however.

Preserved Homologous Arterial Grafts

Although Carrel and his associates and certain German surgeons at the beginning of the twentieth century and shortly thereafter studied fresh arterial homologous transplants in animals, and to a certain degree the methods for their preservation, it was not until 1948 that sound clinical application was made possible. As has been indicated, the primary initial use was in the human aorta, first for application in patients with long coarctations, and subsequently in patients with occlusive disease and aneurysm of the aorta and peripheral arteries. The author has dealt elsewhere with the details of the experimental

Evaluation of Blood Vessel Replacement

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Despite the fact that there are now several tested and standardized commercial synthetic arterial replacements which will have been implanted into several thousand patients this year, uniformity of opinion does not yet exist as to the best type of graft to employ, nor even as to the preferable operation for restoration of blood flow. During the past decade, since the reintroduction of preserved homografts into clinical surgery by Gross and his associates, there has nevertheless appeared a definite trend which can form the basis for certain conclusions. In order to recognize the reasons for this trend, it is important to deal briefly with the experimental and clinical experience with certain of the more popular and successful types of arterial replacements.

Autogenous Vein Grafts

To those who have had experience in tissue transplantation, or who can appreciate the desirability of having suitable tissue always readily available, autogenous vein grafts would seem to offer an ideal source of material. Indeed, following the first use of a free vein graft in 1907 by Lexer, the German military surgeons during World War I made use of such grafts in a number of soldiers suffering from wounds to peripheral arteries. In general, they performed well, despite the obvious handicap of inadequate blood replacement and control of infection. Of particular interest is the review of 63 cases by Bätzner in 1947. One of these grafts, functioning for twenty-two years, demonstrated aneurysmal dilatation. Shortly after this report, there were several series of experimental studies, primarily in America, in which the tendency of autogenous vein

rupture of aortic homografts have been reported. Many of them were not associated with thinning and dilatation of the transplant, however. In some instances, it was believed that the method of processing the graft caused damage to the wall that was undetectable at the time of implantation. In a few instances, an exaggerated host reaction or antigenic response was believed responsible, and in others infection was the cause.

The functional results with preserved aortic homografts in clinical experience appeared to be essentially unrelated to the method of preservation or sterilization. As was observed with autogenous vein grafts, there was a distinctly higher instance of functional success when grafts were used to replace aneurysms or areas of trauma then in arteriosclerotic occlusion. With improved methods of study and more careful selection of cases in peripheral occlusive disease, the functional success here, too, has shown gradual improvement.

However, one main deterrent to continued popularity of aortic homografts was the difficulty in procuring sufficient grafts for increasing clinical material in most major hospitals. Despite relaxation of restrictions on donor material and the prolongation of preservation time by employment of quick-freezing and freeze-drying techniques, increasing interest in the synthetic replacements after their introduction in 1951 was only natural.

Synthetic Prostheses

With the report in 1951 of Voorhees, Blakemore, and Jaretski describing experimental success with a woven taffeta fabric of thin yarn, a new horizon was envisioned. To many small hospitals without facilities for procurement of homografts or proper preservation, the ready availability of synthetics appeared most welcome. However, to others, such ready availability without critical testing or restriction of use to those properly qualified, appeared to be a threat. In order to call attention to the specific physicochemical characteristics of the synthetics and the various types of construction of prostheses suitable for use in mammalian arteries, certain data were published in the surgical literature. Some of the failures in these early years were directly due to technical problems and others to poor se-

and clinical work pertaining to various methods of preservation, but certain references here are essential to an understanding of certain conflicts which developed in relation to the use of preserved homologous arteries.

Initially, it was considered essential that the cells of the transplant be viable, and to this end nutrient solution containing serum and antibiotic agents was the preferred medium with a storage period of only several weeks at 4° C. Subsequently, it became evident that equal functional success could be achieved experimentally with quick-frozen and freeze-dried grafts which were biologically nonviable. At the time when homografts were enjoying their widest use, the most common method of handling graft material was by freeze-drying the material after electronic irradiation of nonsterile tissue. Chemical sterilization by ethylene oxide and later, more popularly, by beta-propriolactone, appeared to be equally effective. Some surgeons, including the author, showed a preference for quick freezing as the method of preservation, and a few reported on clinical experience with grafts preserved in ethyl alcohol.

The experience with preserved arterial homografts in the thoracic aorta has been good in general. The initial one of Gross is still functioning well after eleven years, and other long-term successful results have been recorded, even though significant calcification of the transplant may at times be visible on the roentgenogram of the chest. Long-term studies of canine aortic homografts indicated that after eighteen months there could be expected a significant increase in the amount of calcification noted in the grafts, as well as thinning and spotty disappearance of elastic fibers. Minimal calcification was observed by the author at four and one-half years, and almost complete calcification in as little as four months. Excellent function was noted in three dogs followed for ten years. Despite progressive deterioration and disappearance of elastic fibers, as well as marked thinning of experimental aortic homografts, relatively rare reports of aneurysmal dilatation have been noted. In clinical practice, however, some surgeons have encountered an alarming number of aneurysms of preserved homografts, primarily in those used to replace or bypass the femoral artery. The author reoperated on five such grafts, employing bypass grafts of woven Dacron with continued good functional results. Dilatation and, in a number of instances,

vent unreasonable loss of blood at the time circulation was reestablished. Even now, most knitted replacements are more porous than woven or braided ones by virtue of their method of construction. Extensive experiments with woven fabrics one-fiftieth the porosity of the initial fabric have indicated that functional success is not related to the degree of porosity per se. Indeed, certain responsible investigators now consider porosity of no importance whatsoever in respect to functional success. However, it must be admitted that the degree of incorporation of the synthetic replacement into the host tissues and the organization of the intima depend significantly upon some degree of porosity being present to permit penetration of the graft by fibroblasts of the host into the layer of clot deposited by the circulating blood.

FLEXIBILITY AND ADAPTABILITY TO CONTOUR. These appeared to be most significant characteristics of successful synthetic prostheses. Early experience with straight tubes, regardless of the method of construction of the prosthesis, showed that acute flexion produced kinking and buckling with turbulence and, at times, significant decrease in actual blood flow. That these factors at times produced thrombosis of the prostheses cannot be doubted. Edwards and Tapp contributed significantly in producing a crimped tube which would conform to contour and exhibit certain flexibility. At the present time, the commercial grafts produced according to the specifications of Edwards, Julian and Deterling, and DeBakey are crimped. Szilagyi has favored the use of Helanca yarn, which is twisted in such a fashion as to impart a degree of elasticity. Thus, without crimping the prosthesis itself, flexibility and elasticity can be imparted to the transplant by virtue of the characteristics of the yarn itself.

CHOICE. Insofar as the preference of synthetic material is concerned, Edwards now prefers Teflon, whereas Julian and Deterling, DeBakey and Szilagyi appear to prefer Dacron. It is admitted by all that further improvements in synthetic material may be expected.

Limitations of space prevent mention of the contributions of other serious workers. Emphasis has been given primarily to those prostheses which are now well tested, and standardized and readily available in America. At the present time, it would be quite difficult to claim significant superiority of one over the

lection of clinical cases, as was also true of the use of autogenous vein and preserved homologous arterial grafts.

Materials

Controversies developed as to which of the synthetic materials was indeed most suitable. After several years of rather critical testing by various research groups it may be concluded that, of the materials currently available and suitable for safe use in the mammalian arterial tree, Dacron and Teflon emerge as the most suitable. Although theoretically the latter might seem to be slightly better on the basis of technical information, the fiber is generally more difficult to work with in constructing a prosthesis, and there is no clinical evidence of superiority.

WEAVE, ETC. A similar confusion existed initially regarding the various types of construction of prostheses, and for a time claims of superiority were based on factors such as closeness of the weave, thickness of the yarn, degree of twist and number of filaments per thread, et cetera. The taffeta weave, which was the type of construction of the prosthesis first described, has remained a favorite of many. It is possible to achieve minimal porosity, and hence blood loss, with minimal bulk of foreign material. Braided prostheses have been developed periodically. Braid was the construction first employed by Edwards and Tapp but subsequently Edwards favored a knit and more recently a weave. Sanger introduced a knitted orlon prosthesis and subsequently DeBakey had a knitted Dacron prosthesis of a slightly different type produced.

SEAM. The earliest prostheses of woven material were formed into tubes by sewing a seam. Subsequently, distinctly superior constructions were evolved which were either seamless or essentially seamless with a selvage edge, as in the prosthesis developed by Julian and Deterling. Although, for a time, it was claimed that seams contributed significantly to the development of thrombosis, experimental studies failed to confirm this.

POROSITY. Initially, the degree of porosity of a prosthesis was believed related to functional success, since it was evident that prostheses of impermeable film, glass or metals most frequently failed by thrombosis. Very porous fabrics, such as that initially reported by Voorhees et al., had to be preclotted to pre-

surrounding fibrous tissue with wrinkles developing in the replacement. This complication has been minimized by the use of crimped prostheses, and apparently is not a problem with the Helanca tube. The more tightly constructed prostheses are not readily incorporated in the scar tissue of the host, and tissue can be readily peeled from them at the time of re-exploration. With such grafts there may be a higher incidence of seroma formation.

INFECTION. With all synthetic replacements, infection is a serious threat to continued function and to integrity of the line of anastomosis, although such problems exist almost equally when preserved arterial homografts are employed. Establishment of infection about a synthetic replacement has an additional dangerous feature, since a plane of extension between the prosthesis and host tissues is more readily achieved than between homografts and the surrounding tissues. Accordingly, extension of infection along the course of synthetic replacements is observed more commonly than with homografts. The method of choice in dealing with such an infection is, of course, to remove the offending foreign body. In instances in which the collateral circulation is fully adequate, healing may then take place with no worse symptomatology than was noted prior to insertion of the graft. This is more frequently the case with bypass grafts than with end-to-end replacements. One reason for this is the frequent necessity of sacrificing the terminal collateral when end-to-end grafts are employed for occlusive arterial disease. If the graft is accessible, adequate surgical drainage of the infected area has in some instances been followed by granulation and complete healing with continued functional success. Studies by Harrison have shown that, with infection, homografts most commonly rupture as a result of proteolytic activity, whereas the prosthesis will thrombose. Dehiscence at the suture line may occur on occasion, however, with both types of graft.

Evaluation of Techniques of Implantation

End-to-End Techniques

Initially, most implantations were end-to-end following excision of the affected segment of artery. A very disappoint-

other on the basis of experience reported throughout the country. The functional rate would appear to be equivalent to the technical capability of the operator and proper selection of cases. The variety of sizes offered by certain manufacturers might be considered an advantage. To some, the minimal amount of synthetic material embodied in the prosthesis of Julian and Deterling might seem preferable, especially for use in the extremities or neck. The crimping has been an advantage, rather than a detriment, as feared earlier by some. The commercially available replacements can be cut to length by scissors and suitable branches may be attached by suture technique to windows cut appropriately in the body of the graft.

The Potential of Carcinogenesis

The potential of carcinogenesis enters any discussion relating to the use of synthetic materials and certain drugs in the human body. To date there has been no evidence of carcinogenesis arising from the use of these prosthetics in human cases. The sarcoma in rodents induced by films of these synthetic materials is not comparable, since the Oppenheimers and others conducting such studies have not produced evidence that fabrics made from yarn of these synthetic materials produce malignancy in their test animals.

Complications

It would be untrue to claim that there have been no complications associated with the use of synthetic prostheses. In the early experience with them, when seams were being produced by sewing machines, there were instances of rupture of such seams with fatal or serious hemorrhage. Experimentally, the author observed two grafts of nylon taffeta slowly give way and become aneurysmal. This has been reported by others studying similar types of nylon fabric. These complications have not been observed experimentally or clinically in the commercially constructed prostheses of Dacron or Teflon. Occasionally, there has been noted a subintimal deposition of calcium in experimental animals. Occasionally also, when sufficient tension has not been exerted on the prosthesis at the time of implantation, there has been subsequent contraction of the

quently very large collateral vessels, both proximal and distal to the occlusion, must be sacrificed when replacement is to be effected. Also, one avoids the additional time and blood loss entailed in excising a nonfunctioning segment of vessel, which is generally quite adherent to surrounding tissues by virtue of the inflammatory reaction observed in the adventitial zone of arteries occluded by the arteriosclerotic process.

Role of Anticoagulation

A source of more recent controversy is the role of anticoagulation in patients with transplants. Initially, it was considered unsafe to give either heparin or a prothrombin-depressing drug to a patient with a synthetic prosthesis until several days after the operation. This was based partly on the theory that healing of the anastomosis would be adversely affected by depressed coagulability of the blood and, more important, that there would be increased bleeding through the fabric with the formation of an hematoma about the prosthesis. Failure of a graft has, on occasion, been attributed to such a collection about the vessel. Also, it has been observed that a completely and satisfactorily preclotted graft, which had stopped oozing after implantation, could, on occasion, begin to leak blood again through some area of the prosthesis, presumably because of the washing away of the interstitial clot or even by reason of fibrinolysis. Such secondary blood loss, although fortunately rare, has been observed at periods up to twenty-four hours following the implantation.

In an experimental study, the author reported on the rate and pattern of healing in the reanastomosed canine aorta with and without prolonged anticoagulation by means of Depo-Heparin. No significant effect was observed on the pattern of vascular healing. Grafts have been implanted clinically with the patient under a satisfactory degree of prothrombin depression without untoward effects. With the use of less porous replacements, such as those of Julian and Deterling, and the recent woven one of Edwards, the reliance upon the patient's clotting mechanism and the need for preclotting is minimized. Accordingly, if an implantation is performed in a vessel seriously affected by atherosclerosis, and particularly if intimectomy is necessary in the region of the anastomosis, the author

ing incidence of early and late failure by thrombotic occlusion was observed in patients treated for obliterative disease. On the contrary, results in patients with aneurysm or trauma to an artery, or when a graft was used to extend the length of a vessel, were generally very good regardless of the type of graft employed. The experimental observation that the incidence of thrombosis increased, other factors being equal, with diminution in caliber of the vessel being grafted has held true clinically. Even with recent improvements in fine-suture material and small-caliber synthetic grafts, discouraging results can be expected with transplants in arteries less than 3 or 4 mm. in diameter. This, at present, precludes their use in patients with lesions involving arteries the size of the coronary arteries, tibial vessels or intracranial arteries. This does not mean that such vessels will never be suitably handled, however.

Bypass Techniques

In 1951 Kunlin produced the bypass or skip graft in the treatment of occlusive arterial disease. Shortly thereafter, Cockett, Linton, Crawford and others popularized this method of grafting in vessels with arteriosclerotic occlusions. Extension of its use to patients with traumatic occlusion, and even coarctation, has been reported. While many authors have by now claimed definitely superior functional results with the bypass graft, as compared to end-to-end replacements in similar patients, there has generally been a shorter follow-up period and fewer cases in the series in which bypass grafts were employed.

One cannot overlook certain other advantages of the bypass graft, however. Since the deposition of the atheroma is not infrequently eccentric, there is most often some segment of the circumference of the wall which is relatively free of disease. With the bypass technique the surgeon can select this area for making his arteriotomy and can perform a much more satisfactory anastomosis than could be achieved in an end-to-end fashion. It is the opinion of many that the addition of intimectomy at the site of an anastomosis, sometimes necessary with end-to-end implantation, adds to the chances of thrombotic occlusion. The minimal disturbance of collateral arteries is a significant advantage of the bypass technique, since fre-

answer. During the past few years, when late results in patients with grafts used for peripheral occlusive disease became increasingly disappointing, certain surgeons turned their interests to thrombo-endarterectomy, as popularized by Wylie, Cannon, and others. Except for short occlusions of the aorta and iliac vessels, with reasonably good vessels proximally and distally, the experience of the author has been disappointing. Long segmental thrombo-endarterectomy involving the superficial femoral artery has appeared to be blind, traumatic and as time-consuming as the implantation of a bypass prosthesis. In some instances the vessel may be thinned to the extent that there is either postoperative rupture of the area or late development of aneurysm. Unfortunately, the latter is often unrecognized, owing to the reluctance of most surgeons to perform visualization studies postoperatively in patients who have had successful restorative surgery for arterial occlusive disease. While this reluctance might be considered commendable, it may fail to reveal such aneurysms.

As with venous autografts, the danger associated with infection is less than with homografts or synthetic replacements. It has been claimed that thrombo-endarterectomy, properly performed, can also open the arterial branches of the occluded arterial segment. One serious danger is the thrombosis of all such branches if the artery which has been endarterectomized again occludes. Not infrequently, the vital collateral arteries are also included in this process, and in series reported even by the enthusiasts for this method, there is an alarmingly high incidence of amputations, which were necessary in those patients in whom the thrombo-endarterectomy of the superficial femoral artery failed. This is quite in contrast to the state of the patient with the thrombosed bypass graft. In most instances, this patient is no worse off than before the implantation.

Role of Lumbar Sympathectomy

It appears that lumbar sympathectomy is now being employed with different indications than were respected a decade ago. Currently, sympathectomy may be performed, and preferably only on the involved side, in patients with partial occlusion. Although some surgeons will readily employ a graft in

will generally administer 50 mg. of heparin in the deep subcutaneous tissues as soon as oozing through the prosthesis has ceased, and before closure of the wound has begun. Continuous and adequate anticoagulation with heparin then is carried out for the next few days, with subsequent shift to prothrombin-depressing drugs. However, it would appear preferable to avoid the use of anticoagulant drugs in the early postoperative period.

In some clinics, particularly those in Sweden, surgeons favor institution of the anticoagulant state by prothrombin-depressing drugs several days after implantation and will continue administration of appropriate drugs for prolonged periods of time. In Sweden the current recommendation appears to be for continued use of an anticoagulant as long as the patient lives. In that country, with state medicine being practiced effectively, the financial burden on patients by this method of therapy is relatively insignificant. The inconvenience to the patient and dangers from bleeding should not be overlooked, however.

It will be most valuable to have available long-term data relating to this type of management in the future so that the exact role of anticoagulation in patients with diffuse atherosclerosis who have a grafting procedure for thrombotic occlusion can be more clearly appreciated. Certainly, if there is shown to be a significant reduction of late graft closures or intra-arterial thromboses associated with atherosclerosis—as in peripheral, cerebral or the coronary arteries—one could consider long-term anticoagulation worthwhile. The author does not believe this has yet been demonstrated, and does not therefore advocate prophylactic long-term anticoagulation routinely.

Role of Thrombo-endarterectomy

It has already been mentioned that occasionally some form of intimectomy or thrombo-endarterectomy is advisable in the region of implantation of a prosthesis to achieve a better anastomosis and arterial lumen adjacent to the site of an anastomosis. In some instances this is unavoidable, owing to the extent of brittle calcific deposition in some patients. The question of whether one should employ a graft or perform a thrombo-endarterectomy by preference, however, is a difficult one to

taining sufficient material and the increasing evidence of degeneration of graft material—as demonstrated by calcification, thinning, and even aneurysm formation—have led surgeons to favor the currently available, standardized, and well tested synthetic prostheses. Most of those being used are of woven or knit construction, and Dacron or Teflon seems best suited for safe use in mammalian tissues.

With proper selection of the synthetic prosthesis and the necessary technical proficiency, one might expect from 50 to 80 per cent patency after one year in patients with peripheral occlusive disease, and far better results in those with other conditions. Although some may claim equivalent results with thrombo-endarterectomy in peripheral vessels, there appears to be a greater threat to the extremity if this procedure fails than exists if a bypass graft occludes. The occasional aneurysm formation observed with thrombo-endarterectomy, homologous arterial grafts, and even autogenous vein grafts would make the prosthetic grafts seem preferable for this reason as well.

The author does not yet favor routine lumbar sympathectomy at the time of inserting a peripheral arterial graft, nor committing the patient with occlusive disease to long-term anticoagulation following graft implantation. Certainly, specific indications exist for both, however.

Now that orthodox techniques for graft insertion have evolved, and comparable materials are being employed, valid statistics may be obtained within the next few years to permit a better evaluation of restoration of blood flow by grafting than has been possible to date. The role of sympathectomy and anticoagulation may also be clarified.

such patients, and others do nothing for the time being, still others perform sympathectomy in the hope that there will be clinical improvement observed during the subsequent year. In some instances, this hope seems to be realized.

Some surgeons now favor performing lumbar sympathectomy at the time of inserting a graft in a peripheral artery. It is reasoned that the patient may enjoy the benefits and protection of the sympathectomy if the graft fails in the postoperative period. Recently, it has been shown by Crawford that immediate postimplantation circulation distal to the graft is greatly improved if a lumbar sympathectomy was performed at the time of the implantation.

The author has achieved very satisfactory results in the immediate postoperative period in certain patients with a slightly pale and cool extremity following implantation of a graft, by instituting immediately a continuous or fractional epidural administration of 0.5 to 0.75 per cent Xylocaine. Following the insertion of the catheter into the epidural space, systemic heparinization is carried out. It must be admitted, however, that in other patients with a similarly appearing extremity immediately postoperatively, the foot has appeared pink and warm and with bounding pulses the following morning with none of these measures having been performed. With such variability in the postoperative spastic phase, it is perhaps unreasonable to suggest that all surgeons routinely perform lumbar sympathectomies when implanting a peripheral graft.

Lumbar sympathectomy is now being performed more freely on elderly patients with severe claudication and arteriographic evidence of profound thrombosis involving the distal popliteal and tibial arteries. Benefits in this age group have also been observed with epidural Xylocaine or lumbar sympathectomy shortly after the sudden occlusion of a major collateral pattern. However, this does not imply that sympathectomy under emergency conditions is to be recommended.

Summary

A review of the literature clearly demonstrates changing preferences in blood vessel grafts. Enthusiasm was first centered upon autogenous vein, and subsequently upon homologous artery, particularly for use in the aorta. The difficulty in ob-

unless heparin is used. Heparinization need be carried on no longer than ten days, for by that time a satisfactory endothelial lining will have been established.

The nonwettable characteristics of the plastics used at the present time do not promote clotting in the early postoperative period, but as granulation tissue permeates the fabric wall, and before a mature endothelium can be laid down, clotting becomes a hazard which is enhanced by any period of stasis in a grafted segment.

Advantages

1. No foreign body or devitalized autologous tissue is necessary. The problems of procurement and sterilization are eliminated. Adequate material for repairing is always at hand. Changes in the consistency of the prosthesis, lengthening, and loss of flexibility do not occur.
2. Flow is restored not only from the main channel above to the main channel and its branches below, but also into the small collaterals arising from the endarterectomized segment.
3. Restoration of flow into the smaller branches as well as into the main channel greatly increases the capacity of the outflow tract and reduces the risk of thrombosis, if there is subsequent progression of atherosclerosis in either the proximal or distal vessel.

Indications and Results

Aorto-iliac Obstructions

The relative shortness of the segments involved and the large caliber of the vessels allow excellent results with either endarterectomy or grafting techniques. The average age of the patient with major arterial occlusion limited above the inguinal ligament is about five years less than that of patients with femoral involvement. Many of these patients show no evidence of atherosclerotic involvement of the coronary arteries. This group of patients, then, offers the minimal surgical hazard, maximal opportunity for long-term survival, and a favorable technical situation. In our last 70 cases of endarte-

Thrombo-endarterectomy for Occlusive Vascular Disease*

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The modern era of arterial reconstruction was introduced by a report twelve years ago of "thrombo-endarterectomy" of an arterial segment occluded by atherosclerosis.[2] Soon thereafter, Holden reported a successful reconstruction by venous autograft.[3] Endarterectomy and the use of biological or plastic prostheses or shunts remain the basic techniques for restoration of flow past the site of an atherosclerotic occlusion. The success of both techniques depends upon the segmental nature of atherosclerosis and the presence of patent vessels beyond the level of large vessel obstruction.

Rationale

Endarterectomy is accomplished by direct removal of the occluded intimal "sequestrum" and its associated and contained clot through short, longitudinal incisions in the relatively normal media The medial wall is repaired and within ten days the raw muscle tube re-forms a nonwettable endothelial layer derived from active proliferation of intact intimal layers at the orifices of arterial branches and at the end of the dissection. Ordinarily, the rate of flow through vessels of large caliber, i.e., the aorta and iliac arteries, is sufficiently rapid to prevent clotting; however, when longer segments of vessel are endarterectomized, the flow, which depends upon the fourth power of the radius and upon the inverse of the length of the segment, may be slowed so much that clotting may occur

* This investigation was supported by Research Grant H1787, United States Public Health Service.

Femoral and Popliteal Obstructions

Patients who legitimately belong to the category just described may be erroneously placed in the category of pure femoral and popliteal obstruction by failure to recognize a significant proximal stenosis in the iliac arteries. This error may indeed be the major cause of prompt failure of an otherwise technically perfect graft or endarterectomy in the femoral vessels. Provided, then, that the proximal arterial tree is substantially patent, the choice of technique must be based on the following considerations:

1. Since femoral endarterectomy is in most hands a more exacting procedure than bypass grafting, the procedure cannot be performed quickly, and, therefore, it entails a greater potential surgical hazard to poor risk patients.
2. Endarterectomy in the femoral vessels requires the use of heparin in most instances, and any contraindication to anticoagulant therapy becomes an indication for grafting.
3. The immediate success rate in endarterectomy done for *favorable* cases approximates that of bypass grafting.
4. Long-term follow-up reports on most series of grafts indicate a higher incidence of late thrombosis than occurs in initially successful endarterectomies.

The initial failure rate of endarterectomy in the femoral vessels is almost entirely due to the inability to restore flow into a satisfactory distal tree. If an initial success is achieved, however, and the patient does not die of intercurrent vascular occlusions in other parts of the body, the femoral segments can be expected to remain patent for many years. It is believed that the perfusion of muscle collaterals and such branches as the geniculates contributes to this long-term success rate. It is common, for instance, to find a patient in whom occlusion of either the proximal or the distal vessel immediately adjacent to the endarterectomized segment has occurred without thrombosis of the reconstructed vessel and, indeed, without dramatic change in the extremity except with regard to exercise tolerance.

The experience with femoropopliteal endarterectomy (see Table 1) continues to parallel the previous reports, with follow-up periods of from 14 to 75 months.[1] Thus it seems that the more localized the disease is in the extremities, and the longer

rectomy (for pure aorto-iliac obstructions) there were no operative deaths or surgical failures, and in follow-up periods of from one to six years there were no instances of occlusion of the endarterectomized segment. Occlusion has occurred below the operated area, and in four cases some narrowing of the reconstruction has been recognized.

Aorto-iliac and Femoral Obstructions

This group includes favorable candidates as well as some of the most unfavorable situations encountered by the vascular surgeon. As a group these patients are older and show more evidence of diffuse vascular involvement. The length of the segments involved is maximal, and the caliber of the distal arteries is minimal.

By the same token, it is this group of patients in which impending necrosis rather than limitation of walking forces one to offer some surgical relief. It seems wisest to subject these patients with obstructions of great length to the least surgical procedure possible; only in the unusually young patient with no evidence of coronary artery involvement should one undertake endarterectomy from the renal to the popliteal arteries. Lumbar sympathectomy to protect the integument is the best therapy if major necrosis does not already exist. Actual or impending necrosis unimproved by sympathectomy possibly justifies a reconstruction by a long graft.

In the aorto-iliac and femoral group the author has used endarterectomy in 19 cases. One patient maintained pedal pulses and complete relief of symptoms for seven years, then died of heart disease. There was an operative mortality rate of 10 per cent. There have been six late nonoperative deaths. Only four patients have maintained completely normal pulse patterns; in ten cases femoral pulses persist but distal pulses have failed.

Before advising operation in this group of patients one must assess carefully the hazards and the probable future of the patient as a whole as well as the future of his extremities. Endarterectomy is not the method of choice in this group of cases if reconstruction of both the aorta and the full length of the femoral artery is necessary.

Femoral and Popliteal Obstructions

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TABLE 1. RESULTS OF FEMOROPOPLITEAL THROMBO-ENDARTERECTOMY

	I *Normal Popliteal and Branches*	II *Partially Occluded Popliteal Tree*	III *Totally Occluded Popliteal with No Patent Branches*
Average age of patients	54	58	61
Percentage of cases	26	47	27
Percentage with pedal pulses	80	50	10

the patient is expected to live, the more important it is to offer endarterectomy in preference to a bypass shunt.

Adjunctive Use of Sympathectomy

Lumbar sympathectomy is advocated currently in all femoral reconstructions and in those aorto-iliac reconstructions which are associated with clinically overt signs of vasospasm.

It is not easy to define the role of sympathectomy in the overall picture of the treatments for this disease. The present position stems from the experience that sympathectomy alone failed to relieve the symptoms of claudication and from the belief that sympathectomy does add a measure of protection to the patient with a tenuous vascular supply.

Conclusion

Endarterectomy remains the procedure of choice in arterial reconstruction, but this choice must sometimes be compromised by situations which force one to use the less enduring and, on occasion, less vigorous techniques of grafting. Lumbar sympathectomy is an important adjunctive technique.

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Treatment of Arterial Insufficiency of the Lower Extremities by Lumbar Sympathectomy

Geza de Takats

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Background

In 1925, when some of us were still scraping the adventitia from the iliofemoral segment for a variety of vascular disorders, the removal of the lumbar ganglionated trunk was proposed simultaneously from two surgical centers, thousands of miles apart. Adson at the Mayo Clinic and Diez in Rio de Janeiro, observing the warm dry skin which followed sympathectomy and realizing that the indication of this operation for spastic paralysis was faulty, began to build up a good argument for the removal of the lumbar sympathetic chain in spastic vascular disorders and in hyperhidrosis. Later, the postphlebitic syndrome, the causalgic state, and many other central or reflex vascular phenomena were included among the indications. Reginald Trimble made the significant suggestion, in 1944, that obliterating arteriosclerosis of the lower extremities could be favorably influenced by sympathetic denervation, and while our service had been doing sympathectomies for so-called "vasospastic" phenomena since 1928, it was only after his communication[6] that this widespread vascular disease was surgically attacked in our clinic.

A recent article from this service summarized the previous literature and defined the place of sympathectomy in the treatment of occlusive arterial disease.[1]

The Benefits of Sympathectomy

It is obvious that sympathectomy does not remove any diseased tissue or organ. The operation does free the extremity

from vasomotor and sudomotor stimuli so that the available blood supply will serve the nutritional needs of the limb without being influenced by demands for heat regulation and for maintenance of blood pressure in the erect position. Nor does a central emotional stimulus shut down the arteriolar bed in a sympathectomized extremity. The sympathectomized limb exhibits an even, basal blood flow best measurable with a venous occlusion plethysmograph. When the arterial tree is free of organic disease, as in hyperhidrosis, one can measure a huge rise in blood flow in the first few postoperative days, which however decreases to about twice the preoperative level in a constant environment. The skin temperature, on the other hand, maintains a marked rise of 6° to 10° C. for as long as twenty-five years. The small arteriovenous shunts open and venous oxygen saturation rises.

All this occurs in an extremity whose vessels are free from organic disease. When, however, one is confronted with a vascular tree in which there are multiple, segmental occlusions and stenoses, the benefit of sympathectomy will depend on the capacity of the total vascular bed to dilate on sympathetic paralysis. This in turn depends on (1) the available collateral circulation and (2) the state of the terminal vascular bed. It is important to recognize these two factors, since failure of sympathectomy can thus be foreseen.

Preliminary Tests

There are various ways of measuring the total effect of these two factors. A venous filling time of over 60 seconds, or a flushing time of over 20 seconds is an ominous sign insofar as the beneficial effect of sympathectomy is concerned. Paravertebral sympathetic block may give a good indication as to how an individual extremity is going to behave after vasomotor paralysis (Fig. 1) but one must hasten to state that a paravertebral sympathetic block does not adequately portray the effect of a proposed sympathectomy. In the first place, it is frequently incomplete and produces only partial interruption of sympathetic pathways. In the second place, it cannot reproduce the gradual long-term effect of sympathetic paralysis on collateral circulation. Thirdly, it does not represent the state of a regained intrinsic tone of the terminal vessels, together with a sensitivity

to adrenergic and cholinergic stimuli, which prevails in the chronically denervated, sympathectomized extremity as against the acutely denervated one.

For these reasons and perhaps because the vascular services are busy setting up pump-oxygenators for open heart surgery, a far simpler and more rapid test can be employed. The rise in skin temperature of the plantar surfaces of the toes following a procaine block of the posterior tibial nerve well depicts the transitory change in circulation which occurs after procaine-induced sympathetic interruption and is an adequate indirect estimate of a change in blood flow.[3] In thromboangiitis obliterans and other forms of digital thrombosis, these regional nerve blocks give adequate information about the expected increase of blood flow to the area.

This is not to say that all patients about to be subjected to

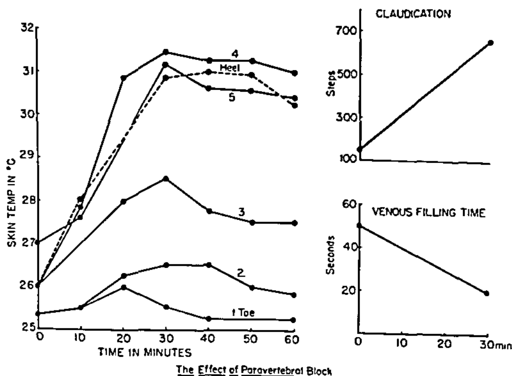


Fig. 1. The effect of lumbar sympathetic block on skin temperature, claudication, and venous filling time. Note the rise to the desirable vasodilation of 31° C. in the heel and fourth and fifth toes. The skin temperature of the third toe rose moderately—that of the first and second toes hardly or not at all The patient's claudication distance increased from 150 to 650 steps. The venous filling time shortened from 50 seconds to 20 seconds. (de Takats: Value of Sympathectomy in Treatment of Buerger's Disease. Surg. Gynec. & Obst. 79:359, 1944.)



Fig. 2. Short segmental occlusion at the upper end of Hunter's canal with short, sturdy collaterals. Both upper femoral and popliteal segments look satisfactory, although the roentgen film is always optimistic. (de Takats: Fundamental Factors Affecting Vascular Surgery. Surgery *41*.444, 1957.)

sympathectomy are in need of such preliminary tests; only those whose digital circulation is in doubt or who show evidence of arteriolar disease need to be tested. There is no paradoxical gangrene after sympathectomy when this safeguard is employed.

Effects on Intermittent Claudication

So far, these tests have been directed toward cutaneous circulation. How is one to know what sympathectomy will do for intermittent claudication, the leading symptom of organic arterial disease?

It is a curious fact that so little is known about claudication. Certainly, a patient who has a short segmental stenosis or

occlusion in Hunter's canal with short sturdy collaterals to bypass it will obtain an increased flow of blood to the popliteal arterial segment and thus to the nutrient vessels of the gastrocnemii (Fig. 2). Who is to say that such a natural collateral will fail faster that a longer homograft or plastic tube sutured to the popliteal artery? These are the early, easy subjects for femoropopliteal bypass, but, should it fail, the extremity is in a precarious condition because the critical popliteal bifurcation is obstructed. Such cases are unfortunately not too infrequent.

On the other hand, an arteriogram indicating poor or no filling of the anterior tibial and tibioperoneal trunks could



Fig. 3. The proximal segment of the superficial femoral artery looks satisfactory. There is no satisfactory distal trunk. Sympathectomy will not relieve claudication in the calf muscles, nor will a bypass succeed, but sympathectomy may save the limb from amputation and favor gradual increase in circulation. (de Takats: Revascularization of the Arteriosclerotic Extremity. A.M.A. Arch. Surg *70*:5, 1955.)



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ger who is forced to walk long distances to hold his job obtains a distinctly greater improvement in claudication than the sedentary worker whose daily walking distance may not exceed that to the corner mailbox.

Another approach to improving claudication after sympathectomy is the use of a combination of adrenergic and cholinergic drugs such as nylidrin (Arlidin) with prostigmine. Such a drug combination is more effective in claudication and the sympathectomized muscle is more responsive to it than the nonoperated side.

What threatens the nonoperated, the sympathectomized and the graft-carrier patient alike is a cardiovascular accident or a sudden thrombosis of a critical segment—the latter often being the consequence of the former. The question that should really be asked is: Is the sympathectomized patient in a better position to withstand a sudden thrombosis in an atherosclerotic limb than the one conservatively treated or the one who carries an arterial or plastic substitute?

✓Prophylactic Sympathectomy

For many years our group has advocated a so-called "prophylactic sympathectomy" of the remaining extremity in vascular amputees. It was thought that such a simple procedure would either forestall the need for, or lower the level of, an amputation in cases of accelerated ischemia due to closure of collaterals. While there is no certain protection, the remaining leg with its burden of increased strain has fared well. Should one advocate a bypass or endarterectomy in such a leg, when it is technically suitable?

Increasing experience would indicate that, when a reamed or bypassed vessel closes in the immediate postoperative period, little if any damage is done to the crippled circulation barring a massive distal thrombosis which lends itself well to immediate flushing or aspiration. But a late closure of a graft upon which the revascularized extremity mainly depends, finds the slowly and painfully developed collaterals unprepared and loss of limb is more apt to occur. This is especially true of bypasses implanted in the popliteal artery, since closure of this artery is critical.

This, per se, is not an argument against femoropopliteal

hardly be expected to show improvement in claudication after sympathectomy (Fig. 3). The operation still has a place in improving the nutrition of the skin and digits. As will be pointed out, postoperative measures combined with sympathectomy may ensure a limited usefulness of the extremity—never as pronounced as if the main vessel is reconstructed.

Between these two extremes of angiographic pattern, there are innumerable variations of multiple segmental involvement of the aortic, iliac, and superficial femoral segments, bridged by comparatively free segments of arteries, in which endarterectomy and short and long bypass procedures are indicated and have proved their value. It should be pointed out, however, that these procedures may and do fail in a certain, unforseeable group of cases, either in the early or in a late postoperative period I have been much impressed with the importance of safeguarding such extremities with a preliminary or simultaneous sympathectomy. This is a far better procedure than doing an emergency sympathectomy when the "direct surgery" fails.

Ancillary Treatment

What is obviously needed is *individual* and not *group prognosis.* Patients with hypertension, diffuse cardiovascular and renal disease, with diabetes or gout are more apt to show an acceleration of their atheromatosis and this should be taken into consideration when the type of surgical therapy is considered. But beyond that, the patient's blood cholesterol should be kept at or below 250 mg./100 ml. While this service has kept atherosclerotic patients on a low fat diet and thyroid extract if necessary since 1939, recent experimental confirmation[5] strengthens our belief that this arbitrary level for blood cholesterol is important, just as a blood sugar level is. Secondly, in unpublished experiments with Ian Duncan Thompson, I have satisfied myself that nothing improves the state of ischemic, claudicating muscle more than systematic graded exercise—an observation well known to clinicians and patients alike. Sympathectomy often does not improve claudication distance but turns muscle cramp into "fatigue." If, over a period of six months to a year after sympathectomy, one urges patients to walk daily, repeatedly to the point of tolerance, one may improve claudication gradually. A mail carrier or a bank messen-

ger who is forced to walk long distances to hold his job obtains a distinctly greater improvement in claudication than the sedentary worker whose daily walking distance may not exceed that to the corner mailbox.

Another approach to improving claudication after sympathectomy is the use of a combination of adrenergic and cholinergic drugs such as nylidrin (Arlidin) with prostigmine. Such a drug combination is more effective in claudication and the sympathectomized muscle is more responsive to it than the nonoperated side.

What threatens the nonoperated, the sympathectomized and the graft-carrier patient alike is a cardiovascular accident or a sudden thrombosis of a critical segment—the latter often being the consequence of the former. The question that should really be asked is: Is the sympathectomized patient in a better position to withstand a sudden thrombosis in an atherosclerotic limb than the one conservatively treated or the one who carries an arterial or plastic substitute?

✓Prophylactic Sympathectomy

For many years our group has advocated a so-called "prophylactic sympathectomy" of the remaining extremity in vascular amputees. It was thought that such a simple procedure would either forestall the need for, or lower the level of, an amputation in cases of accelerated ischemia due to closure of collaterals. While there is no certain protection, the remaining leg with its burden of increased strain has fared well. Should one advocate a bypass or endarterectomy in such a leg, when it is technically suitable?

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bypasses; it is a plea for invariably having the limb protected by a sympathectomy. When it comes to unilateral or bilateral aorticopopliteal bypasses, together with a side-to-side anastomosis to the common femoral artery, one is on even more uncertain grounds. This major, long-lasting procedure, which is accompanied by considerable morbidity, sometimes loss of limb and occasional loss of life, is usually done for patients who defy the original indication for direct arterial reconstructions. Their lesions are not single or multiple segmental occlusions but widespread, generalized vascular lesions accompanied by obstructive atheromatous plaques in other regions. It should be remembered that the claudicant patient is much more apt to die of a cerebral or coronary arterial obstruction than of his peripheral arterial disease. Sixty per cent of patients followed for five years or more remain in a stationary condition; the ones who die usually succumb to a coronary occlusion.[4]

It is desirable that, in this rapidly growing field, surgeons develop impeccable technical skill. Thus the patients who really need it will benefit from the accumulated experience. But it would be unfortunate if this experience had to be gained by operating on a large number of inoperable or probably inoperable cases.

Looking at the other side of the argument, the surgeon who sticks to the simple, time-honored sympathectomy may and does deprive his patient of a new pulsating limb, complete and sudden loss of claudication, and the ability to walk for miles, when he completely ignores endarterectomy or a bypass procedure.

Individual case selection for sympathectomy, for endarterectomy, for bypass procedures is the crux of the problem.[2] Here I would just reiterate that *sympathectomy should precede any other direct restorative measure.*

✓The Arguments Against Sympathectomy

✓Bilateral lumbar sympathectomy including both first lumbar ganglia renders a large percentage of males impotent. Saving *one* first lumbar ganglion seems a good safeguard.

Postsympathectomy neuralgia has been a real problem and much thought has been given to it.[2] At present, early pain relief with narcotics and paravertebral sympathetic blocks to

the proximal cut segment seem to abort most of the long-lasting cases. It is *not* a genitofemoral neuralgia.

A large number of sympathectomized patients are now coming in for endarterectomies or bypass procedures. Does this represent a failure of sympathectomy? I don't think so. These patients now exhibit a clear-cut indication for additional help and should the site of occlusions and areas of degeneration permit a satisfactory transplant, this two-stage procedure will give them the optimal result with minimal risk. But why should a patient submit to an extensive bypass procedure, when he can play 18 holes of golf after sympathectomy while before it his claudication distance was 200 feet?

Present Attitude

The benign, simple procedure of lumbar sympathectomy may be unnecessary when the disease has sympathectomized the patient. This occurs in some types of diabetic neuropathy. It may be useless, when collateral circulation is minimal or when the terminal vascular bed is closed. In the majority of patients suffering from obliterative vascular disease, it will decrease peripheral arteriolar resistance, improve cutaneous circulation and help certain cases of claudication.

Whether or not endarterectomy or a bypass procedure is needed will be discussed in other chapters. Overzealous application of these brilliant technical procedures may add an iatrogenic factor to the problem of atheromatosis. Depending on the temperament and experience of the surgeon, the indications for arterial grafting are widely stretched or too limited. As in other fields of surgical endeavor and after the swings of the pendulum have been stabilized, the clear-cut indications for surgical revascularization of ischemic extremities will emerge. Accurate case selection is more important than whether the plastic material is woven or knitted, porous or not, nylon, Orlon, Dacron or Teflon. Homologous or heterologous arteries for which host tolerance has been produced are the music of the future.

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Thrombo-embolism

Introduction

Much has been written concerning the prevention and treatment of thrombo-embolism, probably because embolism so often can result in sudden death when least expected. The modern program of early ambulation, deep breathing, and avoidance of flexion of the hips and knees postoperatively has been the hope of those who attempt to prevent pulmonary embolism; however, there are some who claim that none of these preventive measures has reduced the incidence of this catastrophe in postoperative patients. It also has been reported that the occurrence of thrombo-embolism is equally frequent in nonsurgical patients. Be it as it may, this dread complication will be with us as long as there are chronically ill patients.

It probably is universally considered that the treatment of thrombophlebitis of the lower extremities, when it is recognized, is anticoagulant therapy; however, the bland type (phlebothrombosis) is not easily recognized and too often is missed completely. Unfortunately, it is this type in which there is thrombosis with little or no inflammatory component which most often leads to dislodgement and embolism. This embolism may be occult or, at the other extreme, fatal. If a nonfatal embolism is recognized by the physician the management of the patient becomes a matter of serious obligation: Does one rely solely on anticoagulant therapy to prevent further embolization, or does one subject the ill patient to the operative procedure of venous ligation to interrupt embolization mechanically? If the physician favors the latter, he still must consider whether the ligation must be done at the superficial femoral vein, bilaterally, or at the inferior vena cava below the renal veins. Whereas superficial femoral vein ligation has been

reported as effective for prophylaxis, it has been found inadequate for therapeusis since the thrombosis of the lower extremities often extends up into the iliac veins. Another disadvantage to ligation at this level is that it requires bilateral ligation because clots may come from the normal-appearing leg.

Therefore the controversy generally rests in the clinical situation in which thrombophlebitis is believed to exist in the lower extremities and a nonfatal embolism is suspected; the decision to use anticoagulant therapy or operative ligation of the inferior vena cava is a serious one for physician and patient. Both viewpoints are supported in the following presentations.

S. R. F.

Inferior Vena Caval Ligation for Thrombo-embolism

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Pulmonary embolism occurs frequently enough with phlebothrombosis to be of major concern to the surgeon. This complication has been reported in one-third of patients with signs of thrombophlebitis. When pulmonary embolism develops, efforts must be directed toward preventing anticipated recurrent emboli.

The fact that the source of the embolus cannot always be determined precisely causes a problem in management. Homans has observed that the greater the swelling and discomfort in an extremity the less danger that a soft, detachable clot exists, and in phlegmasia alba dolens the opposite normal-appearing extremity can be the source of embolism. Other reports call attention to the clinical unreliability of the Homans sign in locating the thrombus, the frequency of unrecognized bilateral thrombosis in the lower extremities, and the frequency with which the pelvic veins have been the occult embolic source. In one series, 50 per cent of patients with pulmonary embolism had no evidence of peripheral deep venous thrombosis.

Advantages of Caval Ligation

Of the various methods of treatment, ligation of the inferior vena cava offers the greatest assurance against the development or the recurrence of pulmonary embolism. By mechanically blocking all sizable venous routes from probable sites of thrombus formation, with the exception of the ovarian and spermatic veins, this single ligation impedes emboli from veins

of both lower extremities and pelvis. While recurrent embolism has been reported, this is exceedingly uncommon after caval ligation.

Disadvantages

Surgeons often are reluctant to ligate the cava because of reported postoperative lower extremity sequelae, including edema, pain, ulceration, and varicosities with associated disability. While it is true that some of these findings are noted in patients who have had caval ligation, their severity has been less than that following common femoral vein ligation, and no more than that following common iliac vein ligation. Comparison of a "conservatively" treated group of patients with iliofemoral thrombophlebitis and a vena caval ligation group of similar severity showed that follow-up symptoms were no greater in the ligation group. Many authors report that the degree of postoperative edema is related to the extent of the primary thrombotic process which has made the ligation necessary and not to the ligation per se. While an obvious disadvantage of this form of treatment is the performance of a major operative procedure in a patient who may be critically ill, most patients tolerate the operation without significant postoperative morbidity or mortality.

Recent Investigative Studies

Recent investigative work has been concerned with the measurement of venous pressures before and after ligation, the choice of ligature material and site of ligation, and the postoperative use of anticoagulants and their effect upon postoperative sequelae.

Nabatoff and co-workers measured venous pressures in dogs prior to ligation of the inferior vena cava. The normal distal pressure of 6 to 10 cm. of water rose to three or four times normal immediately after the ligation but was back to normal twenty-four to forty-eight hours later and thereafter. Anlyan's caval pressure measurements in patients before and after ligation were somewhat similar in that four of seven showed no increase after ligation, apparently owing to adequate collaterals. Other studies by Burch, Dale, and Moretz and co-workers

have shown more persistent distal venous pressure elevations following caval ligation in both dogs and patients.

Streuter and Paine, Dale, and Paulwan have reported investigations in dogs utilizing catgut as the ligature material in order to hasten recanalization of the cava and prevent late sequelae. A theoretical disadvantage of catgut ligation could be early or late pulmonary embolism following deligation, as mentioned by Dale. These studies have shown that when catgut is used the cava will recanalize in most animals in a period of about six weeks. Those ligated with silk did not recanalize.

Thrombosis was noted frequently in the cava below the ligation but this could be decreased by the use of anticoagulants postoperatively. In dogs, low ligation resulted in significantly greater mortality than high ligation, apparently because of absence of distal lumbar collateral veins in low ligations. Pulmonary embolism after caval ligation was not observed in any animal. While the use of catgut ligature in patients has been reported, long-term follow-up studies have not been found in the literature.

Indications for Operation

1. Pulmonary embolism without an obvious site of thrombus formation
2. Progressive deep venous thrombosis with or without embolus extending to the iliofemoral area
3. Pelvic thrombophlebitis with embolism
4. Progressive deep thrombophlebitis which is not controlled by anticoagulants or in which a contraindication to anticoagulants exists
5. Prophylaxis in a patient undergoing other operative procedure who has had or who now has severe thromboembolic disease
6. Recurrent embolization during adequate anticoagulant therapy

Results

Many excellent follow-up studies of series of patients who have undergone caval ligation have been reported. In summarizing an analysis of recently reported follow-up series, Dale stated, "It appears that edema has occurred more often than

not. Whether this is persistent for years, or whether it improves (or worsens) is not always clear, but there are multiple statements indicating the use of elastic external supports and inferring that patient cooperation is important. Reports of return to former occupation or to useful employment imply that some degree of handicap has been overcome. On the other hand, the reports of skin ulcers in the legs were fewer than anticipated and it appears that this ordinarily was not a problem."

Early and Late Sequelae

At the University of Kansas Medical Center, vena caval ligation was done in 32 patients between May 1, 1952 and November 1, 1958, by various resident and staff surgeons. Eleven patients were eliminated from this study since the predominant reason for operation was palliation of intractable congestive heart failure. Two interesting points apropos to this discussion were noted in this group, however. Pulmonary emboli were not reported in any patient after ligation. Autopsies on two patients, one at twenty-four months and one at fifty-two months after ligation with silk, showed that recanalization had taken place. Increased venous collaterals were found along the ureters and in retroperitoneal areas.

In the remaining 21 patients, indications for operation included thrombophlebitis with pulmonary embolism, thrombophlebitis extending to the iliofemoral region without pulmonary embolism, and prophylactic ligation during another operative procedure. There was no operative mortality. One patient died six weeks postoperatively of continued renal failure and congestive heart failure with anasarca.

A recent follow-up study of these patients showed one patient probably dead of carcinomatosis. Seventeen were known to be living. The remaining two patients were followed for one month and nineteen months respectively, when they were lost to follow-up.

In the 20 patients who left the hospital, the average post-ligation follow-up was 29.1 months. The average follow-up period in the 18 patients who had been operated upon at least six months preceding this study was 32.3 months.

Early edema was present in 75 per cent of the 21 patients and was usually of mild degree. Thirty-eight per cent complained of early postoperative pain in the legs.

TABLE 1. LATE POSTOPERATIVE SEQUELAE IN 18 PATIENTS THIRTY-TWO MONTHS (AVERAGE) AFTER CAVAL LIGATION FOR THROMBO-EMBOLISM

Sequelae	*No. Patients*
Edema	
Mild	6
Moderate	3
Requiring use of Ace bandages	7
Pain	3
Restriction of activity	4
Increased varicosities	3
Discoloration of extremity	4
Dermatitis	1
Ulceration	1
Hematuria (bladder varicosities)	1
Recurrent thrombophlebitis	6

Late sequelae were tabulated in the group which has been followed longer than six months and are listed in Table 1. Edema, when present, has been minimal in most cases. Leg pain likewise has not been a serious problem. All patients have been ambulatory; in four patients some restriction of activity or change of work has been necessary. Ulceration was present in only one patient. Four patients have undergone major pelvic and urinary tract operations without difficulty since the caval ligation. There has been no proven recurrent pulmonary embolus in this group following ligation, although chest signs or symptoms which caused the observer to entertain the possibility of recurrent pulmonary embolus occurred in three patients one month, six months, and eight months, respectively, after ligation; the third of these is currently hospitalized in another hospital with symptoms of recurrent thrombophlebitis.

Evaluation of Factors Responsible for Leg Sequelae

It is extremely difficult to evaluate clinically the importance of any one factor in the development of leg sequelae following caval ligation because of the large number of variables and the small number of patients in this series. An attempt to evaluate the importance of anticoagulants postoperatively was made but no significant difference in the leg sequelae could be ascertained in comparing the two groups. Clinically and experimentally evident distal caval thrombosis following ligation reported by others and found in the death in this series would favor the postoperative use of anticoagulant agents.

In the group followed longer than six months, catgut was used for ligature in eight patients and silk in eight. There is little difference in the extent of leg sequelae in these groups. The development of bloody pleural effusion one month after catgut ligation in one patient suggested that pulmonary embolus could have recurred, possibly on the basis of early deligation.

The sites of ligation were studied. All three patients in whom the cava was ligated just above the iliac bifurcation showed some degree of late edema, one with ulceration, whereas late edema developed in two of the four patients in whom the site of ligation was just below the renal veins.

Although the common iliac veins are not routinely exposed at vena caval ligation, clot was observed in the iliac veins in nine patients, with extension into the vena cava in one of these. This high location of the thrombus was suspected clinically in three of the nine patients, but in the remaining six patients the origin of emboli could not be determined or was not suggested by the local findings. Pelvic veins were thought to be the source of emboli in two other patients.

Summary

Phlebothrombosis with complicating pulmonary embolism may occur in multiple and occult sites which may be difficult to identify clinically.

Ligation of the inferior vena cava offers the greatest assurance against the development of pulmonary emboli by mechanically blocking major venous embolic sources.

Follow-up results in 21 patients treated by caval ligation indicate that in most instances lower extremity sequelae have not been particularly disabling to the patient.

No significant difference in the number or severity of late postoperative extremity sequelae was noted whether silk or catgut was used.

There have been no proven recurrent pulmonary emboli after caval ligation in this group of patients.

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The Use of Anticoagulants in Thrombo-embolism

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The prophylactic and therapeutic management of phlebothrombosis, thrombophlebitis, and thrombo-embolism remains controversial. For any specific patient nonsurgical management may be accompanied by pulmonary emboli; on the other hand, surgical therapy may be ineffectual or attended by early or late distressing sequelae. The purpose of this section is to emphasize the nonsurgical approach to the therapy of this disease. It does not mean that surgical therapy should be eliminated. The method of therapy elected should always be that with the lowest mortality and the least morbidity, with specific, individual consideration being given to the needs of each patient.

Etiology, Natural History and Course

The etiology of venous thrombosis is not completely understood. A systemic stress response may produce a more optimal environment for hypercoagulation. The release of excessive amounts of thromboplastin and local tissue factors may aid and abet this state. Venous stasis, or constriction and narrowing by position or dressings are other factors to be reckoned with. An underlying disease process may render the patient particularly vulnerable to embolism, e.g., the cardiac or the debilitated emphysematous patient. A combination of mechanical and metabolic factors makes every surgical patient a potential candidate for thrombo-embolism. An unusual example of this is a young patient who recently died of pulmonary embolism fol-

lowing a minor injury to his thumb. His convalescence had been spent in a chair before a television set.

The natural history and progression of the disease process must be understood. This has been described very well in a paper by McLachlin and Paterson.[1] Extension into the pelvic veins and inadequacy of superficial femoral vein exploration are points to be remembered. The rarity of portal vein thrombosis is also intriguing in this total picture. Finally, the pulmonary arterial response to small and large emboli must be appreciated. The cardiopulmonary sequelae, because of autonomic neural responses, usually far exceed the effects predicted from specific mechanical occlusion of a pulmonary arterial segment. The subsequent effects of increased pulmonary vascular resistance, diminished return to the left heart, decreased cardiac output, and decreased effective blood volume, flow, and pressure, may potentiate the vicious cycle initiated by a silent thrombosis in a distal vein.

Prophylactic and Therapeutic Measures

The specific prophylactic and nonsurgical therapeutic measures logically consist of the following:

1. Adequate preoperative preparation with balanced electrolytes, adequate circulating hemoglobin and plasma protein mass, adequate hydration and renal function, adequate cardiopulmonary status, and adequate hematologic survey.

2. Proper positioning on the operating table to avoid mechanical constriction of leg veins.

3. Careful wound closure with appropriate stainless steel wire retention sutures to permit early ambulation, less hazard of dehiscence, and a shortened period of whole body immobilization.

4. Maintenance of an adequate renal output and regulatory function to avoid decreased effective blood volume and/or hemoconcentration.

5. Early bed exercises and ambulation. The chair has no place in the early postoperative state. An overhead trapeze should be available to every postoperative patient: it permits much greater mobility in bed, and, by stabilizing the shoulder girdle, breathing exercises can be more adequately carried out. Nursing care is simplified.

6. Deep breathing and adequate ventilation, with the avoidance of atelectasis, although these are perhaps of questionable effect on peripheral venous blood flow and venous stasis.

7. Adequate hydration and maintenance of electrolyte balance, pH, and a normal serum osmolality during the postoperative period.

8. Regular, meticulous examination of the patient and his extremities. Bilateral measurements of thigh and calf circumference at fixed points is quite helpful.

9. Careful observation of vital signs. A slight rise in temperature and pulse may be the only prodromal warning of thrombo-embolism a few hours or days later.

Most of these points are regularly observed in the good postoperative care of any surgical patient. They often involve many small details which, in the absence of a thorough knowledge of the etiology of this disease, are important.

The Role of Anticoagulants

Anticoagulants are not routinely administered to all patients, although certain patients with cardiopulmonary disease, pelvic disease, or those who have prolonged immobilization may be prophylactically treated with anticoagulants. The patient with thrombophlebitis or signs of phlebothrombosis is immediately treated with anticoagulants for a week beyond subsidence of clinical evidence of the disease process. Heparin, if used initially, is replaced by one of the dicoumarin derivatives. These techniques have all been described in detail elsewhere.[2, 3]

The debit side of prophylactic anticoagulation must be considered. Inadequate therapy permits extension of the disease process while the attending surgeon is lulled into a false sense of security. Complications of hemorrhage and their attendant mortality may outweigh, in certain instances, the statistical benefit of adequate and prolonged anticoagulation.

The difficult decisions arise when there has been an unheralded pulmonary embolism, or one that has followed adequate anticoagulant therapy. Immediate consideration is given to exploration, not ligation, of the superficial femoral veins, and exploration and ligation of the inferior vena cava. Today, with cardiac bypass techniques, exploration of the pulmonary artery may again be indicated in certain selected early cases

with massive pulmonary embolism. The patient who cannot afford another small embolus should have ligation of his inferior vena cava with exploration of the femoral veins, and removal of thrombi if present. Adequate anticoagulation must be continued irrespective of the institution of surgical therapy, to prevent further extension of the disease process in the pelvis or into the renal veins, or propagation of a pre-existing pulmonary embolus.

Summary

One might say that an aggressive, vigorous, prophylactic surgical attack on this disease process has had little effect on surgical mortality and morbidity statistics. One might further state that a vigorous prophylactic approach with anticoagulants alone has not significantly reduced the morbidity and mortality figures. Each method, or combination thereof, still has its place in our therapeutic armamentarium. Emphasis should be placed on the myriads of small details of excellent preoperative and postoperative care. Early suspicion or diagnosis of thrombo-embolism warrants initial treatment with anticoagulants. Unheralded thrombo-embolism, or embolism in spite of adequate anticoagulant therapy, may warrant a more vigorous surgical approach with the philosophy that one must have a living patient in order to observe any late sequelae.

Conclusion

Adequate anticoagulation is employed as our first therapeutic regimen when thrombophlebitis in any of its several forms is suspected. Anticoagulation, rather than surgical interruption of the great veins, is also preferred for prophylaxis. Surgical exploration and interruption of the great veins of the lower half of the body are employed for specific indications in individual patients.

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Acute Renal Failure

Introduction

The treatment of acute renal failure appears to be in controversy but actually is not. Varying causes, concomitant diseases, and specific biochemical changes are the factors upon which treatment should be based. If any one of these is considered alone, and an individual's experience is likely to be weighted with instances of similar types, the approach tends to be somewhat standardized. In all three of the following discussions, great emphasis is placed on such factors as the cause of renal failure and whether or not wounds and infection are complications. These features are important in the choice of methods of management.

There is a vast difference between the oliguria of renal tubular block caused by hemolyzed transfused blood and that caused by myoglobin precipitation after crushing wounds. Necrosis of renal tubules is more likely to follow prolonged hypotension, in which case hemolysis is not primary, and the sequence of events is rapid.

The choice of treatment is also dependent on the availability of dialyzing apparatus and technicians. The essential guide to proper management is intelligent thought about the individual case.

J. H. M.

Diet and Fluid Regulation in Acute Renal Failure

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During the early period of recognition of acute renal insufficiency as a salvageable disease entity, there was controversy between the proponents of the conservative method of treatment and those interested in trying out the then new artificial kidney. As experience has accumulated, it has been found that the two methods of therapy are complementary and not mutually exclusive. The Army Research group working in Korea demonstrated that nonprotein nitrogen and potassium levels in the blood rise rapidly in the presence of sepsis or tissue necrosis, in spite of careful conservative management.[27] Dialysis is then required as a life-saving procedure. On the other hand, there are numerous patients who have survived renal shutdown due to transfusion reaction, carbon tetrachloride poisoning, and so forth, without the necessity of dialysis.[6, 25]

Principles of Fluid Regulation

Restriction of the fluid intake to between 500 and 750 cc. during anuria (urinary output less than 100 cc. in twenty-four hours) and oliguria (urinary output less than 500 cc. in twenty-four hours) has now become standardized. Balance studies in patients with anuria have shown that the breakdown of body fat and protein together with the release of preformed water yield about 450 cc. of endogenous water daily.[3, 26]

Visible losses of fluid in the form of gastric or intestinal suction are replaced by half isotonic or isotonic salt solutions mirroring the character of the fluid lost, except that the potassium content is not replaced. The daily measurement of body

weight serves as a check on the gain or loss of fluids. A slight weight loss of 0.1 to 0.2 kg. per day indicates a proper balance. Recent animal experiments carried out under this regimen have demonstrated a shrinkage of the extracellular space and an increase in the intracellular space with little change in plasma sodium concentration.[21] In most patients, unless rigidly controlled, there is a tendency to give too much fluid, with a resulting expansion of the extracellular space and a steady fall in the sodium concentration.

Oral Fat and Glucose Diet

There is still some controversy over the best method of administering calories during the period of anuria and oliguria. Early studies of nutrition demonstrated that about two-thirds of the nitrogen excreted during starvation was spared when adequate calories in the form of carbohydrate, or carbohydrate and fat were supplied. Carbohydrate must be present, since a fat diet alone was found to have no nitrogen-sparing effect.[20] Utilizing this information, Borst, in the Netherlands, constructed a diet of starch, sugar, and butter for use in patients with uremia.[4]

Bull, in England, modified this diet to consist of 400 grams of glucose and 100 cc. of peanut oil made up to 1,000 cc., so that it could be slowly dripped into the stomach through a nasogastric tube. This formula yielded an intake of 2,500 calories for each twenty-four hour period. Three of his anuria patients showed an average daily rise in the blood urea nitrogen of 42 mg./1000 ml before going on the diet, and an average daily rise of only 15.5 mg./100 ml. on the diet.[6] Studies of the caloric requirement of patients with acute renal insufficiency of different etiologies have demonstrated an average expenditure of about 2,500 calories per day.[5, 26]

In this country a prepared oral fat emulsion containing 50 grams of glucose and 200 grams of fat in a volume of 500 cc.,* added to 500 cc. of 10 per cent glucose in distilled water, has been used for nasogastric feedings. This formula yields 2,200 calories per 1,000 cc. volume for each twenty-four hour period. In some patients the plasma potassium and nitrogen levels have been easily controlled by this method of nutrition.[1]

* Oral Fat Emulsion, Upjohn Co

In other patients the onset of diarrhea, abdominal distention, vomiting, and the like have precluded its use.

Glucose Intravenously by Simple Infusion

Observation made during World War II studies of starvation and minimal food and fluid requirements for survival brought out other nutritional facts. In one experiment four subjects undergoing a five-day fast showed an average daily nitrogen excretion of 10.5 grams and an average daily potassium excretion of 44 mEq. When 100 grams of carbohydrate per day were given as food, the average daily nitrogen excretion fell to 7.4 grams and the average daily potassium excretion to 26 mEq.[29] Similar studies carried out more recently on postoperative patients receiving 100 grams of glucose a day for the first fours days after major surgery have shown an average daily nitrogen excretion of 6.4 grams and an average daily potassium excretion of 30 mEq.[11] Another series of survival studies demonstrated that a daily intake of 50 grams of glucose did not show significant nitrogen-sparing effect and that an intake of 200 grams per day was no more effective in sparing nitrogen and potassium losses than one of 100 grams.[12]

On the basis of these survival studies, Strauss devised a minimum nutritional intake of 750 cc. of 15 per cent glucose to be given intravenously.[25] Commonly this formula has been modified to consist of 1,000 cc. of 10 per cent glucose for each twenty-four hour period. The large exogenous contribution of water has been ignored and for short periods of anuria without apparent harm, but for longer periods of acute renal insufficiency far too much water is added.

Testosterone Propionate as Adjunct to Control Potassium Levels

Testosterone propionate in doses of 25 mg. a day, in the presence of a glucose intake varying between 50 and 300 grams a day, has been shown to cause an average nitrogen retention of 26 mg. per kg. per day, and a potassium retention of 0.13 mEq. per kg. or about 9 mEq. per day.[7] This response has led to the use of testosterone propionate in a dosage schedule of 50 mg. intramuscularly on the first day, and 25 mg. intramuscularly a day for the next five days, as an adjuvant method of

controlling potassium levels on a low caloric intake.[19] The new testosterone-like derivative, Nilevar,* appears to have the same anabolic properties, but with fewer androgenic effects.[28]

Glucose by Continuous Drip into Saphenous Stump or Vena Cava

Although the simple infusion method described above is capable of tiding patients over a ten to twelve day period of uncomplicated acute renal failure, when fever, infection, and tissue necrosis are present it proves inadequate. The basal metabolic rate has been found to increase at the rate of 7 per cent for each degree rise in temperature.[16] It has been found that, in patients with either burns or peritonitis secondary to a perforated ulcer, the basal metabolic rate averages about 50 per cent, irrespective of fever, and may go as high as 80 or 90 per cent.[9] This seems to account for the large losses of nitrogen and potassium in the urine commonly found in these patients. In the presence of oliguria these substances would be retained in the blood. This observation of an elevated basal metabolic rate in patients with this type of injury also aids in explaining the enormous number of calories required per day (3,000 to 6,000) to establish positive nitrogen balance.[13]

The blood nonprotein nitrogen has also been shown to increase at the rate of 50 mg. per day in similar severely injured patients receiving 100 grams of glucose a day, instead of at the predicated rate of 12 mg. per day for uninjured patients.[25, 27] The plasma potassium level has also been found to have risen 7 mEq. per liter in the first twenty-four to forty-eight hours after injury, instead of increasing slowly at the rate of about 0.3 mEq. per day.[25, 27]

In addition, there is an influx of potassium from dead or dying cells in the region of tissue necrosis. An elevation of the blood phosphorus level to 10 mg./100 ml. with a simultaneous nonprotein nitrogen value of 150 mg./100 ml., giving a P:NPN ratio of 0.06, has been found to be indicative of necrosis in a large muscle mass from which a large amount of potassium may be released [13]

Under these circumstances, all authors advise the use of a long catheter threaded through the saphenous stump or through

* Norethandrolone (17-α-ethyl-17-hydroxynorandrostenone).

an upper extremity vein into the vena cava. By this means a continuous drip of 50 per cent glucose at the rate of 25 to 30 cc. per hour, yielding a total twenty-four hour volume of 500 to 700 cc., may be maintained.[8, 19, 24, 26]

Addition of Insulin and Heparin

Regular insulin, one unit for every 2 or 3 grams of glucose, may be added to the drip just described, as well as 1,000 units of heparin for each 500 cc. of 50 per cent glucose.[8] Since this amount of glucose contributes only 1,000 to 1,400 calories and most patients with acute renal insufficiency have been shown to have higher caloric demands, the beneficial effect on the potassium level seems to be related to continuous tissue deposition of potassium, and this is enhanced by the use of insulin.[19] The heparin is used to keep the catheter from clotting. In this manner potassium levels may be controlled for a period of a few days preceding or between dialyses in severely injured patients.

Intravenous Fat Emulsions

Intravenous fat emulsions have been reported to be effective in lowering plasma nitrogen and potassium levels in patients with chronic uremia.[2, 23] However, these patients were still capable of excreting urine and restriction of the fluid intake was not a problem. Whether there is any advantage in the use of this method in patients in acute renal insufficiency remains to be seen. One unit of intravenous fat emulsion contains 75 grams of fat and 20 grams of glucose in a volume of 500 cc.; this yields a calculated value of 755 calories per unit.* Within the minimum requirements of 700 cc. of volume intake per day and 100 grams of glucose, a combination of 200 cc. of 50 per cent glucose and 500 cc. of intravenous fat, yielding 1,155 calories, would be required. Seven hundred cubic centimeters of 50 per cent glucose would yield 1,400 calories. Thus there would appear to be no advantage of this method over that of concentrated glucose, except where a larger fluid intake is permissible, as in the early stages of the diuretic phase.

* Lipomul I.V. (Upjohn).

Ion Exchange Resins

The use of ion exchange resins may also be included under the general topic of diet. A daily dose of 50 grams of an ammonium form of a carboxylic cation exchange resin, made into a paste with glucose and water and taken orally in small amounts at hourly intervals, has been shown to control potassium levels in patients with acute renal insufficiency. In one patient with the crush syndrome and multiple fractures as much as 215 mEq. of potassium was found in the stool over a four-day period of oral resin therapy.[15] The use of a retention enema consisting of 25 grams of resin in 250 cc. of water, given twice daily, after preliminary cleansing of the rectum, has been reported to be equally effective in removing potassium.[10] The inability of some patients to retain the material sufficiently long, the absorption of the enema water with excess water loading, and the formation of resin concretions in the rectum have, however, offered practical difficulties in some patients.

In patients without increased metabolic demands, resins may be withheld until the potassium level shows evidence of increasing, in spite of an adequate carbohydrate intake. But in those patients with acute renal insufficiency in the presence of infection, burns, multiple injuries, etc., resins are best started early, in anticipation of a rapid rise of the plasma potassium.[15] Under these circumstances, even though it is known that artificial dialysis will eventually be necessary, the use of resins may delay the necessity of the procedure for a few days, thus reducing the number of dialyses required to maintain the patient until diuresis occurs. Resin therapy following artificial dialysis has been found to be quite effective in maintaining the reduced plasma potassium level.[24] In the presence of hidden abscesses or masses of necrotic muscle, however, all procedures, including repeated dialysis, fail to control the potassium level. Dialysis followed by appropriate surgery seems to be the only solution to this problem.[22]

Electrolyte Replacement Therapy

There is still some controversy over the role of electrolyte replacement therapy in the treatment of acute renal failure. Those using the oral fat and glucose diet claim that no such

therapy is indicated.[6] Those involved with the care of surgical patients recommended the addition of electrolytes for specific purposes, not simply to restore the plasma concentrations to normal. It now seems to be established that the fall in the plasma concentration of sodium and chloride ions may be due entirely to an intracellular shift of these ions, or to a combination of intracellular shift and water overloading.[21] By the time the bicarbonate level has fallen below 15 mEq. per liter there usually is a decrease in the calcium concentration with a concomitant increase in the concentration of potassium and phosphorus. At this period the addition of calcium to the daily infusion is advised. As much as 100 cc. of 10 per cent calcium gluconate and 50 cc. of 7.5 per cent sodium bicarbonate* (44 mEq. of sodium) per day has been recommended as an addition to the daily glucose and water requirement. In this manner the antagonistic effect on the myocardium of both sodium and calcium ions for potassium is utilized to block the lethal response to a rising potassium level.[18]

During oliguria there is very little loss of electrolytes by way of the urine, because of the small daily output. Studies obtained during the latter part of oliguria (days 8–13) by Bluemle et al. on eight patients showed an average daily urine excretion of 185 cc. The twenty-four hour electrolyte excretion during the period averaged 16 mEq. for sodium, 5 mEq. for potassium, 12 mEq. for chloride, and 0.9 gram for nitrogen.[3]

As urine flow begins to increase there is a period during which the excretion of water and salt appears to outstrip that of potassium and nitrogen. The nonprotein nitrogen and potassium levels rise paradoxically with the increase in urine flow. The retention of fluid received by the patient prior to recognition of the state of anuria, or of that absorbed from enemas received during the course of therapy, increases the total body water content, thus providing a larger space for distribution of potassium and nitrogen. Under these circumstances a rising urine flow results in a shrinking space and a rapid increase in the plasma concentration of potassium and nitrogen. Failure to replace the volume of the previous day's output of urine in addition to the daily glucose and water requirement has, under these circumstances, been found to be disastrous.[5]

* Calcium ions are infused separately from bicarbonate ions in order to avoid precipitation in an alkaline medium.

Once the diuretic phase (twenty-four hour urine output of 1,000 cc. or more) has become established, the volume of urine lost per day is sufficiently large to bring about considerable electrolyte loss. After one or two days the plasma potassium level may fall, and subsequent daily replacement of this ion is required. Further studies of the same group of patients during the diuretic phase of recovery from acute renal insufficiency (days 14–22 after onset) by Bluemle et al. demonstrated an average daily urine output of 2,300 cc. The twenty-four hour electrolyte excretion for this period averaged 141 mEq. for sodium, 51 mEq. for potassium, 102 mEq. for chloride, and 8.3 grams for nitrogen.[3] Calculation of the urine concentrations of electrolytes from these data yields the following values: 61 mEq./L. for sodium, 22 mEq./L. for potassium, 44 mEq./L. for chloride, and 3.6 grams of nitrogen per liter of urine. These values approximate similar ones reported by others.[14, 26] In the absence of urine analysis for electrolyte concentration, they constitute a pattern for replacement therapy for each liter of urine passed. Thus 500 cc. of 5 per cent glucose and 500 cc. of glucose and isotonic sodium chloride yield 1,000 cc. of volume containing 77 mEq. of sodium and 77 mEq. of chloride ion—a somewhat higher concentration than the above average calls for, but sufficiently close for clinical purposes. After two days of diuresis the addition of 20 mEq. of potassium chloride per liter of urine passed, and the substitution of 500 cc. of $\frac{1}{6}$ molar sodium lactate (83 mEq. of sodium) for the sodium chloride in one of the liters of replacement would control the potassium and bicarbonate blood levels. Urine analysis for electrolyte concentrations is a more accurate method of balancing the daily replacement and can be used as a check against these average values.

After the potassium level has returned to normal and the nonprotein nitrogen has fallen below 100 mg./100 ml., the ability of the kidneys to remove nitrogen, as demonstrated by the increase in filtration rate, has improved sufficiently so that a low protein diet is permitted.[1] Except for the necessity of maintaining a large fluid intake and administering a gram of sodium bicarbonate daily for a week or so as compensation for the inability of the kidney to concentrate urine and to remove acids, the dietary therapy of the patient recovering from acute renal insufficiency is over.

Summary

It would appear that previous lack of recognition of the various metabolic patterns present in the disease states commonly associated with acute renal insufficiency has given rise to controversy over therapy.

The combinations of dietary and fluid balance procedures available at present have been discussed in relation to the metabolic demands occurring during the course of recovery from acute renal insufficiency.

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The Use of the Artificial Kidney in Acute Renal Failure

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Acute renal failure complicating surgery is almost always the result of prolonged selective renal vasoconstriction which leads to the development of widespread areas of renal tubular degeneration. An exception is acute renal failure which follows excessive intravascular hemolysis, where the renal tubules are blocked with acid heme Shock, dehydration, and/or extensive tissue damage is often evident in the early clinical picture of patients who develop the post-traumatic form of oliguria, but not all such patients develop the renal complication. Therefore, a diagnosis of lower nephron nephrosis cannot be made until resuscitation has been accomplished and a patient is in a reasonable state of hydration. Then, if urine output continues below 20 cc./hour and there is no ureteral or urethral obstruction, severe renal tubular necrosis should be suspected.

The Consequences of Acute Renal Failure

Sudden failure of renal function is followed progressively by predictable changes in the "milieu intérieur" of the body which, if not controlled or corrected, are incompatable with life. The degree of initial renal damage is of prognostic significance but so, too, is the degree of associated disease or injury in other tissues. It is not uncommon to see diminished urine output for twenty-four to seventy-two hours following an extensive surgical procedure in an elderly patient. Thereafter renal function progressively improves. Careful postoperative

management is the only therapy necessary. At the other end of the scale, however, are patients who died with acute renal failure regardless of modern therapeutic aids.

Post-traumatic renal failure has a higher mortality rate than the post-transfusion type. In the former group, artificial hemodialysis is often mandatory whereas in the latter group it is less common although at times essential.[5] In both types of renal failure similar physiologic and biochemical derangements result, but in post-traumatic renal failure these usually occur more quickly and in consequence are more severe. Water is not excreted adequately and therefore is retained in the body in excess. The concentrations of plasma potassium, phosphorus, and organic acids rise whereas plasma sodium, calcium, and bicarbonate levels decrease. Nonprotein nitrogen in the form of urea, uric acid, creatinine, etc., accumulates in plasma and uremia results. Possibly other unknown substances accumulate in uremic plasma and cause deleterious effects.

The three common lethal factors in acute renal failure are overhydration, potassium intoxication, and unknown factors associated with the syndrome of uremia. Medical measures will control these for a time but, as indicated above, are insufficient in most patients with severe post-traumatic renal insufficiency; artificial hemodialysis must also be used.

Artificial Hemodialysis

In this technique, blood is removed from the radial artery and passed through a cellophane tube which in turn is dipped into a large bath of electrolyte solution. Blood is returned to the patient via a convenient vein, often the median cubital. The cellophane tubing has a capacity of about 800 ml. and is sufficiently long to allow reasonably prolonged dialysis of blood as it progresses through the tubing. Nonprotein nitrogen retention products pass through the dialyzing membrane (tube wall) into the fluid in the bath. Water and electrolytes diffuse freely so that in time equilibrium is established on either side of the membrane. Blood continuously recirculates from the body through the dialyzing tube for about six hours while heparinization prevents clotting. Bath fluid is maintained at body temperature and discarded every two hours.

Two types of artificial kidney are in common use. The Brigham-Kolff machine (Fig. 1) utilizes a large horizontal rotating drum around which the dialyzing tube is spirally wrapped. The dependent portion of the drum dips into a bath of electrolyte solution so that, as the drum revolves, the cellophane tube is repeatedly bathed in the fluid. Arterial pressure and the rotating motion of the drum drive blood through the tubing. More recently, Aoyama and Kolff[1] have described a stationary disposable twin-coil dialyzing tube (Fig. 2). This unit is easier to use and very effective. Blood is taken from an artery or the inferior vena cava via the saphenous vein and pumped through horizontally oriented cellulose tubing and then returned to the body. A second pump forces electrolyte solution in a surrounding bath vertically between the cellulose coils. The bath fluid is continually recirculated and is changed every two hours. With the latter machine, blood flow is maintained at about 200 ml./minute. The dialyzing surface is about 18,000 sq. cm. and this gives urea clearances of from 78 to 133 ml./minute.

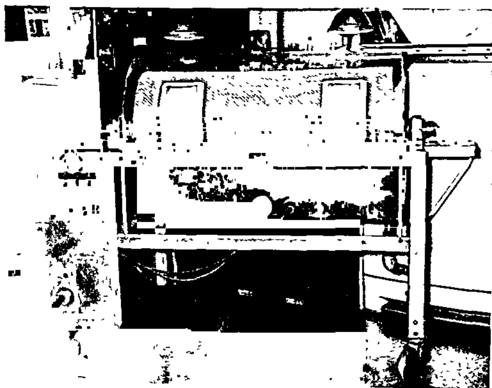


Fig. 1. Brigham-Kolff machine (Renal Laboratory, Georgetown University Medical Center.)

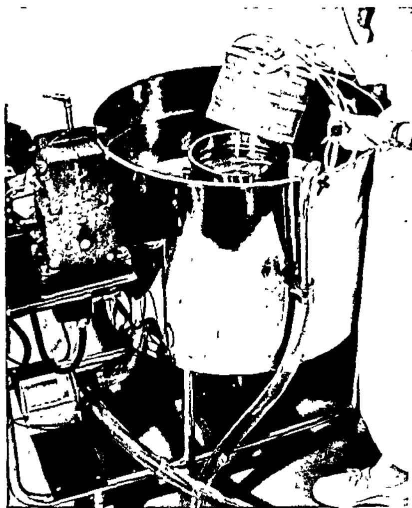


Fig. 2. Stationary disposable twin-coil dialyzing machine. (Renal Laboratory, Georgetown University Medical Center.)

Indications for Artificial Dialysis

There are two principle indications in patients with acute renal failure. The first is a rapid rise in serum potassium. A serum potassium of 7 mEq./liter or above is distinctly dangerous in that the margin for further rise to a lethal level is narrow. If there is complicating infection or associated tissue damage, then serum potassium may rise so rapidly that this indication for hemodialysis is urgent. A changing electrocardiographic tracing will indicate danger of potassium intoxication if the serum levels are not available. In the limb leads the angle between the S wave and the ST segment widens. P waves disappear; T waves diminish in height and become rounded. QRS widening occurs and eventually a curve resembling a sine wave develops.

Artificial hemodialysis lowers serum potassium very effectively.

The syndrome of clinical uremia also responds well to hemodialysis. As uremia develops the patient becomes lethargic, tremulous, and somewhat indifferent of surroundings. Nausea, hiccups, and vomiting occur and convulsions and coma may supervene later. Gastrointestinal bleeding may also occur. Clinical uremia is apparent when the nonprotein nitrogen reaches a level of about 250 mg./100 ml. and this usually takes five to seven days to develop. Dialysis should be instituted with the appearance of clear-cut symptoms of uremia, especially if they are associated with a rising nonprotein nitrogen. Associated pulmonary edema and hypertension are additional indications.

How Soon After the Onset of Acute Renal Failure Should Artificial Hemodialysis Be Utilized?

Serum potassium may rise to 7 mEq./liter or above within twenty-four to forty-eight hours of onset of oliguria if there has been extensive tissue damage. Artificial hemodialysis should be used then. In other patients, several days may elapse before rising serum potassium is a problem (see Table 1).

Artificial hemodialysis must be used to counteract clinical uremia when the syndrome is manifest.

Hemodialysis may be required for the above indications three or more times before spontaneous diuresis occurs and as often as every two or three days. Diuresis does not usually begin before eight or ten days and twenty-two days may elapse before onset.[1]

The Problem of Associated Tissue Damage

Our experience with post-traumatic renal insufficiency in Korea[4] re-emphasized the importance of close attention to the underlying surgical problems. The renal lesion should be considered as a serious complication of a primary surgical disease; it is often not the only complication. Artificial hemodialysis cannot compensate for the nonrenal problems. Therefore the surgeon must retain overall responsibility for the care of such patients, utilizing "renal experts" as working consultants in the

treatment of the kidney component. Wounds must be inspected frequently and debrided repeatedly to eliminate gross amounts of necrotic tissue. Secondary hemorrhage must be controlled and infection aggressively treated. The control of the effects of acute renal failure is much more difficult in the presence of serious wound complication even if the artificial kidney is used.

The Problem of Infection

Infection is a frequent complication of acute renal failure. This is particularly true of the post-traumatic form. Whether or not there is a predisposition to infection because of the renal lesion is not clear, but the available experimental evidence does not seem to suggest such a cause-and-effect relationship.[2, 3] In any event, all severely injured patients are subject to a high incidence of complicating infection regardless of whether or not renal failure results. And, as stated above, infection renders the specific management of acute renal failure much more difficult. Almost one-half of our oliguric patients died of complicating infection even though we had managed to control the specific effects of renal shutdown. Initial careful wound management is therefore very important, with repeated attention thereafter. Sources of infection should be continually looked for and rigid aseptic techniques must be used. Intravenous catheters for fluid administration should not be used longer than absolutely necessary. Antibiotic prophylaxis should be given, but dosage must be lower than usual because blood levels build up rapidly in oliguric patients. Potentially toxic drugs such as streptomycin, polymyxin, and neomycin should not be given.

Results

The fatality rate from post-traumatic renal insufficiency remains high even when the artificial kidney is used. But these patients are usually suffering from multiple injury and have several serious problems. Table 1 shows the results obtained in 11 patients with the above diagnosis who were studied consecutively at the Renal Insufficiency Center in Korea. All patients were dialyzed one or more times Although only two survived, these would not have survived without the

TABLE 1. CLINICAL COURSE OF 11 PATIENTS REQUIRING HEMODIALYSIS WHO WERE ADMITTED TO THE RENAL INSUFFICIENCY CENTER, KOREA

Patient No.	*Serum Potassium on Admission* (mEq./L.)	*Day of First Dialysis After Admission to Renal Center*	*Final Result*	*Day of Death After Admission to Renal Center*	*Apparent Cause of Death*
89	6.2	4	Died	21	Peritonitis, gastrointestinal hemorrhage
91	7.1	6	Died	8	Myositis
92	7.5	4	Died	5	Multiple lung abscesses
102	6.7	3	Recovered	—	—
104	8.2	1	Recovered	—	—
108	7.3	4	Died	8	Myositis
125	6 9	2	Died	3	Undetermined
128	8.0	1	Died	1	Retroperitoneal hemorrhage
129	7.0	2	Died	8	Myositis
133	7.0	3	Died	6	Septicemia
137	7.9	1	Died	2	Undetermined

use of the artificial kidney; the effects of renal failure per se were controlled in the nine patients who died of other complications.

Barlas and Kolff[5] reviewed their experience with 16 patients who had sustained severe transfusion reactions. Twelve seriously ill patients were treated with dialysis, and three of the 12 died. The other four patients recovered without dialysis.

Thus, careful medical management, supplemented by artificial hemodialysis, usually controls the abnormalities resulting from acute renal failure. Because such abnormalities may be lethal, this control is essential. It is equally clear that such management is only one facet in the therapy of such patients. Other derangements, either apparent or unknown, which are responsible for the high fatality rate associated with this syndrome must also be sought for and treated.

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Peritoneal Dialysis and Intestinal Perfusion in Acute Renal Failure

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Statement of the Problem

The occasional surgical patient who develops acute renal shutdown because of shock, tissue necrosis, transfusion reaction, intravascular hemolysis, or toxic agents may require adjunctive treatment in addition to dietary and fluid-electrolyte management. Necessity for removal of uremic metabolites is increased in the presence of infection and tissue necrosis but is not a substitute for the specific management of these complications.

Vivodialysis with the artificial kidney is the most rapid and most efficient method now available to restore water and electrolyte homeostasis toward normal and to remove uremic metabolites. While extracorporeal hemodialysis is not indicated in every patient with acute renal failure, the decision to employ this adjunctive measure should not be delayed until the patient is moribund and transportation is impractical. Ideally, when the diagnosis is established, patients with acute renal failure should be transferred to an artificial kidney center in order that vivodialysis may be done expeditiously if the clinical course warrants. A sufficient number of these centers are now located in strategic geographical locations to make this approach feasible.

While this represents the ideal, it has not been attained and is not attainable in patients whose injuries or clinical condition preclude transportation. For this reason, evaluation of other methods for the management of this problem is appropriate.

The Object of Management

During the oliguric phase of acute renal failure, potassium intoxication and pulmonary edema are the greatest potentially lethal factors. Hyperpotassemia is accentuated by acidosis which is related to accumulation of anions, including phosphate, sulfate, and organic anions, and is aggravated by chloride administration.

The *major chemical objectives in acute renal failure* are removal of potassium and correction of acidosis. Secondarily, the removal of retained anions and organic metabolites will make the clinical course of the disease more benign.

These objectives can be accomplished by peritoneal dialysis, although less efficiently than by hemodialysis. Water, potassium, and urea removal and correction of acidosis by sodium absorption and chloride removal are achieved by intestinal perfusion; significant removal of phosphate, sulfate, and organic anions is not attained.

Peritoneal Dialysis

Use of the 2 square meter surface area of peritoneum as a semipermeable membrane has been reviewed by Grollman[1] and by Merrill.[3] For the occasional application of peritoneal dialysis, practical considerations often require that it be done by a surgeon without special training who must rely upon the materials commonly available in the average hospital central supply room.

Technique

A modification of the method of Grollman has been described.[4] Essentially, this consists of intermittent peritoneal infusion-aspiration of an appropriate sterile dialyzing solution for twelve to fifteen hours.

Two to 4 liters of the solution are infused by needle paracentesis, after which a plastic catheter is inserted by trocar for subsequent withdrawal and reinfusion of fresh solution every two hours

The modification of Grollman's dialyzing solution[4] resembles in composition the normal extracellular fluid with the fol-

lowing exceptions: Potassium and magnesium are omitted in dialyses for acute renal failure, since adequate evidence exists that plasma concentrations of these ions are increased. The concentration of chloride, 80 mEq. per liter, is lower than the normal plasma value but probably represents a more desirable concentration for the uremic patient with acute renal failure because of retention of fixed anions. The lowered chloride concentration helps prevent the development of "chloruremia" and acidosis which have been observed with higher chloride concentrations. Removal of excessive amounts of potassium or magnesium will not occur in the usual peritoneal dialysis for acute renal failure by omission of these electrolytes. Assuming equilibrium of the peritoneal dialysate with plasma, total body potassium would be decreased only about 0.2 per cent by each liter of dialyzing fluid. Prolonged dialysis over a period of days would, of course, require the addition of potassium, magnesium, and additional chloride to prevent depletions of these substances. Only rarely is this a practical consideration, however. Phosphate and sulfate are not used because of retention of these anions.

Indications

The primary indication for peritoneal dialysis is potassium intoxication, present or imminent, as represented by a serum potassium concentration of over 7 mEq. per liter or an increase, in this elevated range, of over 1 mEq. in twenty-four hours. This chemical indication should be supported by electrocardiographic changes of hyperkalemia, consisting of increase in amplitude or tenting of the T waves which may progress to disappearance of P waves, disintegration of QRS complexes, sine waves, and cardiac arrest.

Water intoxication with pulmonary edema has been alleviated by using a more hypertonic solution for dialysis and this may represent an occasional indication in a critically ill patient.

Contraindications

Recent laparotomy tends to contraindicate peritoneal dialysis because of drainage of the dialysate solution through the incision or previously established drainage sites and be-

cause of frequent presence of ileus with distention. Peritonitis is a contraindication because of the associated distention.

Effects of Peritoneal Dialysis

During a sixteen hour period of intermittent peritoneal dialysis, reduction of the serum potassium concentration toward the normal range, partial alleviation of acidosis and reduction of azotemia by about one-third of the initial value may be achieved. Water can be removed in amounts proportional to the osmolarity of the dialysate solution employed.

Intestinal Dialysis

Intestinal perfusion has been employed to remove uremic metabolites and to maintain water and electrolyte homeostasis. Behavior of the intestinal mucosa as an active rather than a passive semipermeable membrane with regard to electrolytes has engendered some difficulty in the composition of perfusate solutions, but it is generally agreed that physiologic conditions for desired water and electrolyte transfers exist, while sufficient nitrogen, chiefly as urea, may be removed in uremia to maintain overall nitrogen balance with moderate azotemia.

Methods

Reported methods of gastrointestinal dialysis have been reviewed.[4] Removal of uremic metabolites by gastric or duodenal aspiration is limited by the relatively small volumes available. Perfusion of the large bowel through an appendicostomy or use of enemas may be helpful in removing potassium, but nitrogen removal is negligible. Gastric lavage may be complicated by vomiting and unpredictable diarrheal losses. Oral use of ion exchange resins is difficult in the presence of nausea, and constipation has been an undesirable sequel. Resin enemas have been reported to remove 21 to 73 mEq. of potassium per day but are also said to produce impaction. A method for gastrodialysis, employing a semipermeable collodion-glycerin membrane balloon in the stomach to remove potassium and uremic metabolites, is being evaluated by us. Removal of

70 mEq. of potassium per day suggests its application to the management of potassium intoxication.

Intubation of the small intestine beyond the ligament of Treitz by any type of tube will result in the bowel being milked up on the tube by peristalsis, with decrease in available mucosal surface area. This is a common operative finding in patients having laparotomy after intubation of the intestine with a long tube. As a temporary expedient, however, intubation and perfusion of the bowel with a multiple-lumen tube may be quite effective. Peroral intubation and perfusion of the duodenum with distal collection of the perfusate obviates the objection of using a long tube within the small bowel.

Perfusion Solution

Because the intestinal mucosa is an active membrane, unlike the peritoneum or cellophane, electrolyte concentrations in the perfusion solution must be formulated in accordance with the exchanges obtained. For acute renal failure these concentrations would be about one-third of the normal serum sodium and chloride, with sufficient calcium to simulate the normal plasma concentration. A detailed evaluation of the perfusate composition at a flow rate of 2 liters per hour in a patient with isolated jejunal segment perfusion for chronic uremia has been reported[5] and may be used to approximate the concentrations necessary for intestinal perfusion in acute renal failure. Although the isolated jejunal segment procedure and perfusion may be of value in selected cases of chronic uremia, it has no apparent application to the management of acute renal failure.

Indications

As in peritoneal dialysis, potassium intoxication is the prime indication for intestinal dialysis. The choice of either of these methods for the management of this complication depends upon the severity of the hyperkalemia and presence of contraindications. Its ideal application is the removal of potassium early in the oliguric phase to prevent later development of toxic hyperkalemia. Inadvertent administration of potassium to a patient with oliguria, early in the course of renal shutdown, represents an ideal application of intestinal perfusion.

Contraindications

Peritonitis, adynamic ileus, intestinal obstruction, gastrointestinal bleeding, and gastrointestinal anastomoses are contraindications to intestinal perfusion, while nausea and vomiting limit its use.

Effects of Intestinal Dialysis

The management of potassium intoxication by intestinal perfusion has not only been effective but in one report fatal hypokalemia resulted from intestinal perfusion in which potassium was omitted from the perfusate. We have removed 7 mEq. per hour by perfusion of the entire bowel. It therefore seems probable that hyperpotassemia accompanying acute renal failure may be corrected by intestinal perfusion. While adequate amounts of urea can be removed, this is not necessarily desirable in acute failure since urea is probably nontoxic, and the increased plasma osmolality resulting from urea retention may actually promote earlier diuresis. No evidence that creatinine is toxic exists and plasma uric acid concentrations would be expected to increase at a rate of only 1 mg. per cent per day with anuria. Possible toxic effects of other uremic metabolites such as phenols and guanidine have not been defined clearly, but bacterial action in the intestinal tract has been established as the source of some of these.

Results with Peritoneal Dialysis and Intestinal Perfusion

Increased knowledge of measures to prevent acute renal failure and of the dietary and fluid-electrolyte management of this derangement, combined with increased availability of the artificial kidney for hemodialysis, has resulted in limited recent clinical experience with these techniques. Because of increasing availability of equipment and personnel for hemodialysis, it is unlikely that any sizable number of patients with acute renal failure will or should be managed solely by either peritoneal dialysis or intestinal perfusion. Inferential evidence for their occasional clinical application is available in controlled studies in animals, and in occasional clinical situations. Peritoneal dialysis has been used to maintain nephrectomized dogs

for as long as 111 days.[2] Intestinal perfusion procedures do not approach this duration of survival but can be shown to remove large amounts of potassium and urea.

As Grollman states, "On the basis of our present knowledge, acute renal failure should become a rare occurrence with a low mortality, except in such cases where it is merely an accompaniment of irreversible and fatal damage elsewhere than in the kidney."[1]

Summary

When facilities, including personnel, for vivodialysis are not available and transportation is not feasible, peritoneal dialysis may be of value in the management of the complications of acute renal failure. Although less effective than peritoneal dialysis, intestinal perfusion may be helpful in preventing or treating potassium or water intoxication.

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Preoperative Preparation of the Colon

Introduction

One of the greatest scientific advances in medicine and surgery has been the development of antibiotics for infections and, more recently, the delineation of specific antibacterial agents for specific purposes. There is no doubt that physicians and surgeons in their sincere wish to benefit their patients have abused the privilege of using such medications indiscriminately, nonspecificially, and even without the indication of infection. More recently, after experiencing more and more evidences of misuse, after witnessing the development of bacterial resistance and even attributing deaths to complications of antibiotics, there has arisen a general apprehension regarding the flagrant or routine use of antibiotics.

On the above basis, a controversy appears to take shape in the field of surgery: The question is whether or not to take advantage of the scientific advances of antibiotic preparation of the bowel as an aid in operating upon the intestinal tract of patients. To employ intestinal antibiotics routinely creates the possibility of the risk of unbalancing "Mother Nature's" bacterial balance of intestinal flora, thus removing the natural inhibition of organisms which are antibiotic-resistant. Staphylococcic enterocolitis has occurred as a result of the use of intestinal antibiotics; on the other hand, peritonitis probably has been prevented in countless instances because of their use.

It is emphasized that the administration of antibiotics on indication is an aid to the surgeon and should not be a crutch. The controversial question is not that antibiotics tend to make surgeons careless in their reliance on antibiotics, because the

ideal surgon must be technically careful and use all available aids intelligently and without abuse of the principles of surgery. The controversy is whether to employ the aid of intestinal antibiotics routinely when operating on the intestine.

S. R. F.

Preparation of the Bowel for Intestinal Surgery Without Resort to Antibiotics

Leland S. McKittrick
Harvard Medical School

In a period during which tremendous advances have been made in surgical procedures and the increased safety with which they may be done, it is difficult, probably impossible, to satisfactorily evaluate the many responsible factors. It is easy to overemphasize one factor to the detriment of another that is even more important. The antibiotics, rightfully or not, have been given much and, I suspect, too much credit for the improvements which we all enjoy, especially in gastrointestinal surgery. It has always seemed to me that to overemphasize the antibiotics might easily result in underestimating the significance of some of the more basic principles involved. Because of this and because of my own conviction that the use of the antibiotics represents only a factor and a minor factor in the improvement of our results, I have thus far completely avoided their use, either in the preparation of the patient for operation or as a routine part of their postoperative management.

Objectives of Preoperative Preparation of Patient

In the preparation of the patient for intestinal resection there are two components: the preparation of the patient and the preparation of the intestine. With varying degrees of anemia and malnutrition common to many patients with carcinoma of the bowel, it is essential that every effort be made to correct any such deficiency which may be present; and since conditions which assure maximum safety for any surgical experience are of such great importance to each individual, the length of

ideal surgon must be technically careful and use all available aids intelligently and without abuse of the principles of surgery. The controversy is whether to employ the aid of intestinal antibiotics routinely when operating on the intestine.

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In the preparation of the patient for intestinal resection there are two components: the preparation of the patient and the preparation of the intestine. With varying degrees of anemia and malnutrition common to many patients with carcinoma of the bowel, it is essential that every effort be made to correct any such deficiency which may be present; and since conditions which assure maximum safety for any surgical experience are of such great importance to each individual, the length of

time spent in the preparation for operation is of little significance. Time, therefore, as an argument in favor of any given method of preparation of a patient about to undergo an elective operation, should receive little, if any, consideration. Whatever time is needed should be taken in an effort to bring the patient to the operating room in a state of reasonable nutrition, an adequate level of hemoglobin (12.5 grams or more), and in the best possible physical and emotional condition.

The second component of our objective is the proper preparation of the bowel. A bowel which is clean and dry is a safe bowel to anastomose. If a bowel is clean and dry and a resection is technically well done, there will be no leakage and no significant infection. A patient who is in the best possible physical and emotional condition with a bowel that is clean and dry is well prepared for resection.

Methods of Preparation

Minimal Obstruction

Although our objectives may be clear-cut, their attainment is not always accomplished. To do so in a high percentage of cases requires from five to seven days and consists theoretically in cleansing the bowel of its contents, then utilizing a diet which is high in protein and low in residue in an effort to provide the more significant dietary needs and at the same time leave a minimum of residue in the bowel.

Cleansing of the bowel is obtained by active catharsis. We still prefer castor oil, 30 to 45 cc., depending upon the needs of the individual. With the giving of the castor oil the patient is placed on a diet which is high in protein and low in residue. He is encouraged to eat lean meats well chewed, milk products, eggs, fish, and strained vegetables. Forty-eight hours later a second dose of castor oil is taken, the amount depending upon the result from the previous dose. After the second dose a daily saline enema is given.

Since the sulfonamide derivatives, succinylsulfathiazole (Sulfasuxidine) and phthalylsulfathiazole (Sulfathalidine), are essentially nontoxic and probably aid in lessening the bowel content, one of these is given in doses of 9 grams daily for a period of five days preceding operation. We have a slight

preference for Sulfathalidine in the unobstructed bowel; with some degree of obstruction present, *Sulfasuxidine seems to* soften up the contents a little better and is our choice. Operation is planned after five full days of preparation. If the patient is in good general physical condition, the preparation is started at home; he is admitted to the hospital so as to have two full days there before the operation is undertaken. If the condition of the patient is such as to demand a longer period of preparation, additional time is allotted. This is rare except when the general condition of the patient is unduly poor or when the degree of obstruction present warrants somewhat more protracted bowel preparation.

Partial Obstruction

Patients with varying degrees of obstruction present somewhat more of a problem in preparation. Certainly, in many of these instances the ideal of the objectives is not attained. Frequently a period of seven to ten days of preparation may well be justified in an effort to attain the objective, since the general nutritional state of these patients as a rule is not as good, and they present as well a greater problem in bowel cleansing.

Often, depending upon the degree of obstruction, a routine single dose of castor oil may not seem desirable. In certain of these instances we may shift to one of the saline cathartics, as magnesium sulfate or citrate of magnesia, in small doses at hourly *intervals, sort of feeling our way along, varying the* amount depending upon the response of the patient. Usually if additional time is taken and if the diet is kept very low in residue, ultimate cleansing will occur and the patient and his intestine will be in proper condition for a primary resection.

Complete Obstruction

Patients with complete obstruction present a wholly different problem. Whereas we are prone to resort to cecostomy in an emergency acute obstruction of the left colon, we recognize that only rarely does this give proper background for satisfactory preparation for resection. If in five or six days after emergency cecostomy the patient does not begin to have spontaneous bowel movements, satisfactory preparation either

of the patient or the bowel will probably not be accomplished. Under these conditions, after the exact location of the lesion has been determined, proximal colostomy is carried out and the needed time is taken for adequate preparation.

If transverse colostomy has been necessary we merely cleanse the distal bowel by irrigations and do not instill any antibiotics or chemotherapeutic agents to lessen the bacterial flora.

If at the time of operation we find that we have failed in our effort to have a relatively clean bowel, it is our custom to milk as much as possible of the bowel contents into the segment of bowel to be removed. This usually results in a bowel that is relatively clean and dry when the resection clamps are applied.

If the patient is in a reasonably good state of nutrition, if the bowel is clean and dry, and if the basic principles of intestinal anastomoses have been carried out, the use of antibiotics either before or after operation is unnecessary.

The Use of Antibacterial Agents for Preoperative Preparation of the Colon

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Interest in the gastroenteric bacterial flora and its modification is not of recent origin. Escherich in 1886 conducted the first systematic study of the intestinal flora. He observed that sterilization of ingested food had little or no influence on the number or character of the organisms in the bowel. Pasteur first posed the question of whether or not an intestinal flora is necessary for the well-being of the host. Bouchard (1887) seems to have published the earliest studies on intestinal antisepsis.

The Agents

Sulfaguanidine was employed for a brief period in 1940 as an intestinal antiseptic but was abandoned for this purpose when its ineffectiveness in the presence of ulcerative lesions in the gastroenteric tract was demonstrated and approximately 25 per cent of patients showed sensitivity to the drug at the required dosage level.

Poth and Knotts first described succinylsulfathiazole (Sulfasuxidine) in 1941. Poth and Ross introduced phthalylsulfathiazole (Sulfathalidine) in 1943 as an intestinal antiseptic. Both of these drugs are still used for this purpose, but I have preferred a combination of neomycin and Sulfathalidine since 1950.

Recently kanamycin has been advocated as a substitute for neomycin. Kanamycin has not been used sufficiently to permit definite conclusions and its use should be restricted until

it can be proved safe and superior to the neomycin-Sulfathalidine combination.

Combinations of antibacterial agents must be used cautiously, because they may be antagonistic, as in the case of oxytetracycline and neomycin reported by Pettet, Judd, and Dearing.

Desirable Properties of an Intestinal Antiseptic

The period of postoperative paralytic ileus coincides with the time of early healing of bowel anastomoses and the inability to take drugs orally. Consequently, it is the most important period during which intestinal antisepsis should be maintained. Antibacterial agents should for these reasons be stable in the presence of digestive ferments and foods and retain their local, topical effect by not being absorbed from the gastrointestinal tract. They should be nonirritating to the mucous membranes and other local tissues, thus permitting maintenance in sufficient concentration to ensure bactericidal activity against pathogenic organisms and prevent the outgrowth of drug-resistant pathogens especially when the natural balance of the normal flora of the bowel has been upset.

When the bowel is normally active, the oral administration of the antibacterial agent should not be less frequent than every four hours, otherwise the antiseptic will be swept out of the upper portions of the bowel and favor the outgrowth of resistant strains of organisms. The intestinal lumen affords an ideal environment for bacterial growth, because the contents of the bowel are maintained at nearly constant temperature and humidity and the essential metabolites for microbial growth are kept within tolerable or even optimum limits in a biologically steady state. The antibacterial agents should neither cause a dehydrating diarrhea nor interfere with the mechanical emptying and preparation of the colon.

The procedures used to prepare the bowel bacteriologically should neither complicate the preparation nor increase the time required.

The Neomycin-Sulfathalidine Combination

This combination fulfills all of the above specifications and, as of today, is the best of the many substances and the com-

binations proposed for the purpose of decreasing the hazards of surgery of the colon inherent in the threats of infection.

Indications

Patients fall into three groups as regards the practical application of intestinal antisepsis. This division can best be summarized in tabular form (Table 1). Purgatives may be given in Group 1 and the first dose of the neomycin-Sulfathalidine combination is given simultaneously. The period of preparation is less than twenty-four hours. Group 2 is comprised of those individuals with bowel obstruction which can be aborted by gastric suction. As soon as the patient can take water by mouth, the antibacterial combination can be given. Bacteriological preparation will be realized even before mechanical emptying will have been accomplished. Group 3 consists of those individuals requiring urgent abdominal exploration where definitive preoperative preparation of the bowel is proscribed. The antibacterial agents are here administered

TABLE 1. CLINICAL CATEGORIES OF INDIVIDUALS REQUIRING INTESTINAL ANTISEPSIS AND THEIR MANAGEMENT*

Group 1 No Obstruction, Purgation Not Contraindicated Preparation in 20 hours or less Castor oil 60 cc., neomycin 1.0 gm., and Sulfathalidine 1.5 gm at 1 P.M. Then neomycin 1.0 gm. and Sulfathalidine 1.5 gm at 2 P.M., 3 P.M., 4 P.M., 8 P.M., 12 midnight, 4 A.M. and 8 A.M. Operation scheduled for 9 A.M. *Group 2. Partial Obstruction, Purgation Contraindicated* Gastric suction [illegible] neomycin 1.0 gm. and Sulfathalidine 1.5 gm given by mouth every 4 hours until mechanical preparation of the intestine has been accomplished, usually a minimum of 3 days	*Group 3. Complete Obstruction, Intra-abdominal Trauma, Perforations of Intestine, Peritonitis Preoperative Preparation of Intestine Contraindicated* Exploration as soon as general condition of patient warrants Evacuate peritoneal cavity Add 200 cc. of 0.5 per cent solution of neomycin to peritoneal cavity† Evacuate intestine Flood intestine with as much as 1,000 cc. of 1 per cent solution of neomycin containing 250 units per cc. of bacitracin if available Evacuate peritoneal cavity, place 100 cc. of 0.5 per cent solution of neomycin into peritoneal cavity† Wash wound with 0.5 per cent solution of neomycin during closure†

* *Adult doses are given in this table. Children should receive about one-half these quantities and infants about one-fourth (Modified from Edgar J. Poth, J.A.M.A. 163:1317–1322, 1957, Table 2.)*

† *Addition of bacitracin in a concentration of 500 units per cubic centimeter might be indicated.*

through the wall of the bowel after the abdomen is open. Sulfathalidine cannot be given in this instance, because it is not soluble. Either neomycin alone or a combination of neomycin and bacitracin is injected into the lumen. Cultures of a suspension of feces aspirated from the lumen yield the following results:

Time of Contact	*Relative Bacterial Growth*
Zero Time (Control)	100%
5 Minutes	10%
10 Minutes	1%
15 to 30 Minutes	0%

These patients are operated upon as soon as their general condition warrants.

It is emphasized that in none of these groups is the operation delayed or mechanical preparation interfered with due to the use of the neomycin-Sulfathalidine combination.

There are conditions other than primary bowel lesions which deserve the protection afforded by intestinal antiseptics. Extensive intra-abdominal operations which may result in cloudy swelling of the liver are an indication.

Specifically the deeply jaundiced patient, the patient undergoing correction of coarctation of the aorta or portacaval vascular shunting, and the individual operated upon for extensive pilonidal disease are proper candidates. Stubborn cases of chronic urinary tract infection due to Escherichia coli frequently clear up when the bowel is rendered practically free of organisms Intestinal antiseptics should be administered early during the period of observation of diverticulitis of the colon and whenever mesenteric thrombosis is suspected.

Hazards and Methods of Meeting Them

The most hazardous period of intestinal antisepsis is when it is discontinued. The bowel contains essentially no bacteria, and the antibacterial agents may be evacuated rapidly. The stage is now set for the first organisms ingested to become established and grow uninhibited. Should the organism be a variety of Micrococcus pyogenes (Staphylococcus) capable of elaborating a potent enterotoxin, pseudomembranous enterocolitis may develop. This complication has never, to my knowledge, occurred following the administration of only the neomycin-

Sulfathalidine combination. Theoretically it is possible. Therefore, the neomycin is discontinued several days before stopping the Sulfathalidine. This procedure permits the nonpathogenic alpha Streptococcus fecalis to become re-established, and it will prevent the wild overgrowth of staphylococci and development of pseudomembranous ulcerative enterocolitis. One of the parasympatholytic drugs such as Pamine will prevent the severe diarrhea, dehydration, and electrolyte imbalances following ileostomy, hold the antibacterial agents in the jejunum and ileum, and avoid pseudomembranous enteritis.

Yeasts always multiply following suppression of the bacterial flora. Primarily they represent a nuisance causing occasional perianal excoriation and diarrhea. Ordinarily these complications can be controlled with oral Vioform and topically applied Vioform ointment. The more persistent infestations may require Nystatin administration.

Evaluation of Intestinal Antisepsis

Is any practical benefit derived from the use of antibacterial agents designed to alter the bacterial flora of the gastrointestinal tract prior to and immediately following surgical procedures? If there are any benefits, do they outweigh the cost, bother, hazards, and nuisance which result from the use of the combination neomycin-Sulfathalidine?

Claimed Undesirable Effects

THE COST. The cost is less than that of one day's hospitalization. Usually no antibiotics are given postoperatively, and there is a strong possibility the overall cost of medication is less.

THE BOTHER. The effort expended in preparation is less than required when purgation and enemas are used for mechanical emptying of the bowel, because, as is illustrated in group 1, no enemas are given to disturb the patient on the morning of the operation.

THE HAZARDS. True sensitivity reactions are almost unknown. Some instances of nausea are encountered and rarely an individual may vomit the tablets. The vomiting is practically always on an emotional basis; tablets will be vomited

while suspensions will be retained. There has been no occasion on which the medication could not be given because of vomiting. Systemic reactions are rare and mild since little of the drugs is absorbed.

Yeasts always multiply and occasionally cause diarrhea and perianal irritation. Vioform usually terminates these episodes with the occasional need to use Nystatin. Systemic moniliasis has not developed.

Pseudomembranous enterocolitis is always a possibility. It has not occurred in my series of cases and can be circumvented if the proper procedure for withdrawal of the drugs is observed and the parasympatholytic drugs used concomitantly when indicated.

The Benefits

IMPROVEMENT IN BOWEL HEALING. Comparison of the manner of healing of the bowel reveals both grossly and microscopically striking differences between animals (dogs) acting as controls when the enteric tract is emptied by purgation alone as contrasted with purgation plus neomycin-Sulfathalidine. The effects are essentially the same as those reported by Poth, Ross, and Fernandez (1945) using Sulfasuxidine and Sulfathalidine respectively as the antibacterial agents. Specimens taken from control animals all showed walled-off perforations or peritonitis and extensive edema of the bowel wall by the anastomotic technique selected to give a suitable test object. Microscopic sections across the suture line on the fifth postoperative day show extensive polymorphonuclear infiltration, multiple small abscesses, necrosis of the cut edges of the bowel, inhibition of capillary ingrowth, and thrombosis of arterioles and other small vascular radicles. The specimens obtained from treated animals showed no perforations or peritonitis. Edema was minimal The microscopic sections reveal moderate leukocytic infiltration principally by round cells and plasma cells. There is active proliferation of capillaries containing intact red cells. There is no evidence of vascular thrombosis.

A series of studies has been done on the influence of intestinal antiseptics regarding healing of the large and small bowel following damage to the blood supply. Ligation of the arteries and veins to a 50-cm. segment of distal ileum so that the sole

blood supply is via the vessels in the wall of the bowel at the ends of segment results in death of 65 per cent of animals within forty-eight hours with nearly complete dissolution to the middle half of the devascularized segment. These changes are so extensive that it is inconceivable that elimination of the bacterial flora in the lumen of the bowel would in any way alter the process. It is utterly astounding that 95 per cent of the animals treated with the neomycin-Sulfathalidine combination survive.

Another series of experiments consisted of dividing the mesenteric arteries and veins to 10 cm. of distal ileum, transecting centrally, and re-anastomosing. All control animals died following disruption of the anastomosis while all the animals treated with the combination neomycin-Sulfathalidine survived without evidence of postoperative morbidity. The lumen was of normal caliber at the anastomotic site.

IMPROVEMENT IN MORTALITY AND MORBIDITY RATES. The results obtained in 184 consecutive cases of carcinoma of the colon treated by resection and primary open anastomosis are given in Table 2. It is rather unexpected that no operative deaths occurred in 166 consecutive cases in which intestinal antiseptics were used, especially in view of the average age of these patients. Attention is specifically directed to two items —postoperative temperature elevation and wound infections. Gross infection occurred in 78 per cent of abdominal wall wounds when intestinal antiseptics were not used as compared to 2.8 per cent when neomycin-Sulfathalidine was given preoperatively according to the schedule outlined in Table 2, *C* and *D*, and 3.8 per cent when *E* of Table 2, where preoperative preparation is precluded, is considered together with *C* and *D*. One hundred and sixty-six consecutive primary resections with open anastomoses and without decompressing enterostomies for carcinoma of the colon are significant when complications such as leakage at the suture line, localized abscess formation, fecal fistula development, or peritonitis have not been encountered even once The elevation of temperature postoperatively (Table 2, *D*) where the bowel had been prepared preoperatively with neomycin-Sulfathalidine and the peritoneal cavity and abdominal wound washed with 0.5 per cent neomycin solution at the time of operation, is somewhat lower than that observed following simple hernioplasty in pa-

TABLE 2. ONE HUNDRED EIGHTY-FOUR CONSECUTIVE CASES OF CARCINOMA OF COLON TREATED BY PRIMARY OPEN ANASTOMOSIS

*Group**	*No. of Cases*	*Bowel Preparation*	*Operative Mortality*	*Postop Temp 101° F.*†	*Wound Infections*
1 & 2	18	A Purgatives and enemas	11%	100%	77 7%
1 & 2	35	B. Sulfasuxidine	0	54%	5 7%
1 & 2	58	C. Neomycin-Sulfathalidine	0	35%	3.4%
1 & 2	51	D. Neomycin-Sulfathalidine Neomycin irrigation	0	26%	2 0%
3	22	E. No preop preparation. Neomycin instillation and irrigation	0	36%	9.1%

** Groups 1 and 2 are charted together since there is no essential difference in results in the two groups.*

† Rectal temperature readings of 101° F. or more on one or more occasions postoperatively.

A Mechanical preparation using castor oil and enemas. All patients receive parenteral antibiotics postoperatively.

B. No purgation or enemas Sulfasuxidine 3 gm every 4 hours for 7 days. Parenteral antibiotics only if temperature exceeds 101° F. rectally.

C Neomycin-Sulfathalidine orally preoperatively—divided about 20 per cent Group 2 and 75 per cent Group 1. [illegible] 101° F. rectally.

[illegible] irri- [illegible] 1° F. rectally.

E. Group 3—No preoperative preparation of the bowel possible. Bowel partially decompressed at time of operation. Bowel filled with 1 per cent neomycin solution at time of operation Peritoneal cavity and abdominal wound irrigated with 0 5 per cent neomycin solution. Resection and primary anastomosis done in the presence of complete obstruction and distention of proximal bowel. Decompressing enterostomies not done. Parenteral antibiotics usually given both preoperatively and postoperatively.

tients of the same age group operated upon at the same seasons of the year by the same surgeons. Apparently the neomycin absorbed from the peritoneal cavity and the wound is sufficient to give appreciable general protection from mild pulmonary infection. This thesis is being tested experimentally.

Spillage of the altered fecal contents of the bowel into the peritoneal cavity carries little or no danger and permits open anastomoses with more accurate approximation and better preservation of the local blood supply. While every precaution should be taken to avoid tension and ischemia, the neomycin-Sulfathalidine combination will give positive protection against ischemic necrosis.

Comment

Stasis of the contents of any hollow viscus favors the development of infection by invasion of otherwise relatively benign contaminants. The bowel is a hollow viscus in which

stasis is present during postoperative paralytic ileus, and its contents is most certainly highly contaminated with potentially virulent organisms. As tone and peristalsis return and progress distally along the bowel, stretching the more distant atonic segments, conditions are favorable for invasion of the traumatized tissues at the site of anastomosis.

It would be superfluous to elaborate on the observations made on the difference of healing with and without intestinal antisepsis, because when healing of an anastomosis in the colon following alteration of the bacterial flora simulates primary wound repair, it is significant.

It should be emphasized that this discussion has been restricted to the use of the combination neomycin-Sulfathalidine in the specific dosage schedules given in Table 2 for intestinal antisepsis, because certain substances and combinations of substances are not only useless but their use is hazardous. The tetracyclines actually favor the outgrowth of staphylococci in the bowel. Staphylococci are not resistant to neomycin alone in the concentration maintained in the bowel during active therapy, but the addition of oxytetracycline allows staphylococci to grow out and is a hazardous combination. Intestinal antiseptics cannot be used haphazardly. Their use must be properly regulated. Their effect is relatively specific.

Conclusions

The *proper use of the combination of neomycin-Sulfathalidine* as an intestinal antiseptic as a complementary procedure to supplement proper surgical therapy, in which the recognized safeguards of good surgical practice are maintained, eliminates the hazards inherent in infection in conjunction with colon surgery. While this complementary adjuvant lessens the hazards even in the hands of the most competent surgeons working under ideal conditions, the greatest dividends accrue to the less expert physicians who actually perform the vast majority of colon operations under the existing conditions of medical practice in this country.

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Prolapse of the Rectum

Introduction

It is likely that the sliding cul-de-sac herniation through the transversalis fascia of the pelvic diaphragm has always been associated with true rectal prolapse; however, the cause-and-effect relationship has not been appreciated (by anatomists, pathologists, or clinicians) for centuries. This relationship does not easily lend itself to understanding and it is not until the "sliding into an intussusception" is visualized that the discovery of the cause of the prolapse is made It then easily follows that the treatment of the prolapse is the correction of the causal hernia.

There appears now to be no controversy regarding the concept of pathogenesis of true prolapse and, as a result, the multifarious methods of correction have been narrowed down considerably. There remain only two general methods of operative treatment of the hernia about which there is legitimate controversy. One method employs an abdominal approach; the other a perineal approach. The advantages and disadvantages of each are nicely pointed out in the following two presentations.

S. R. F.

The One-Stage Perineal Operation for Prolapse of the Rectum

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Surgical care of a true rectal prolapse is difficult under any circumstance. Unfortunately, the condition is seen most frequently in aged or debilitated patients who are often unable to stand formidable transabdominal procedures. To eliminate the possible hazards and complications of a transabdominal repair in such poor-risk patients, a one-stage operation with a perineal approach was reported by the senior author, Paul Hoxworth, and Jerome Giuseffi in 1952[1] for the cure of extensive prolapse of the rectum. It was a modification of the first stage of the two-stage operation previously described by Dunphy.[3] Further experiences[2] with this procedure have confirmed our initial conviction that it is curative, and that it merits wide use.

A Classification of Prolapse

In the differential diagnosis of rectal prolapse it must be understood that there are three types. The following classification is used in our clinic.

Type I is a protrusion of the mucous coat of the rectum for a distance of 1 to 3 cm. only, the mucous membrane being redundant, hypertrophied, and abnormally loose. It is the most common form, represents a false prolapse, and is usually associated with hemorrhoids.

Type II consists of a protrusion of all layers of the rectum. It is essentially an intussusception which starts at a level above the anus and which is therefore an incomplete prolapse.

Type III is a true or complete prolapse of the rectum which is in reality a sliding hernia of the pelvic peritoneum or cul-de-

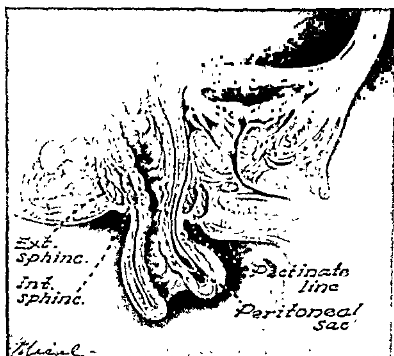


Fig 1. Diagrammatic illustration of a true rectal prolapse indicating the presence of herniation of the cul-de-sac through the anterior rectal wall. (Figs 1 to 5 from Altemeier, W. A , Hoxworth, P. I , and Giuseffi, J., S Clin North America, October, 1955)

sac through a defect in the pelvic diaphragm. The cul-de-sac hernia invaginates the anterior wall of the rectum to produce an intussusception through the rectal and anal canals which protrudes through the anal sphincter (Fig. 1).

The third type is seen most frequently at the extremes of life, in children and in the aged, with predilection for the female. The absence of the sacral curve, and the presence of wasting diseases, diarrhea, and poor bowel habits are thought to predispose to the development of a prolapse.

In children the first and second types of prolapse are usually seen.[9] The nonoperative treatment of prolapse has been frequently curative in infants and young children, but ineffective in adults. Conservative treatment is not only unsuccessful in adults, but it also results in frustration and depression of the patient, retirement to an invalid-type of life, and the necessity of excessive nursing care.

The Problem in Type III (True Prolapse)

The elderly patient with Type III prolapse shows either the obese or thin visceroptotic habitus, and frequently has evi-

dence of hernia in other locations. Many have severe degenerative diseases, such as coronary thrombosis, cerebral thrombosis, cerebral arteriosclerosis, or psychiatric disturbances. Such factors have increased the risk of operation and multiplied the problems of preoperative and postoperative care.

A review of published data[4-8] on rectal prolapse emphasized the facts that Type III has been difficult to cure, and that recurrences have been common. Pertinent factors emphasized include the following:

1. The lesion is essentially a sliding hernia.
2. A large defect is present in the transversalis fascia and the levator ani muscles of the pelvic diaphragm.
3. Continuation of the prolapse produces relaxation, stretching, and eventual paralysis of the external sphincter muscles.
4. The rectosigmoid and sigmoid colon are characteristically elongated and redundant. The associated mesentery is thickened, heavy, and redundant.
5. Patients with this condition are often poor surgical risks.

The one-stage procedure under consideration may be used in both Type II and Type III prolapse, but it is particularly efficacious and more specifically designed for Type III complete prolapse.[1, 2]

Procedure

Preparation of the Patient

Patients so afflicted are given a thorough diagnostic study and all evidence of associated or complicating disease is noted and treated as indicated. The bowel is then prepared for operation by catharsis, followed by the introduction of a low residue diet which is changed to a liquid diet one day preoperatively. Succinylsulfathiazole (Sulfasuxidine) is administered for four days, and neomycin for thirty-six to forty-eight hours, prior to the procedure. Cleansing saline enemas are given the day and night before the operation. Adult patients are given a low spinal anesthetic and placed in the lithotomy position. An indwelling Foley bag catheter is inserted to drain the bladder throughout the operation and the first five postoperative days. The operative area is cleansed by scrubbing with a suitable de-

tergent or soap and water for ten minutes, painted with an antiseptic solution, and draped in the usual manner.

Techniques

The apex of the prolapsed rectal mass is grasped with Allis clamps, everted, and pulled downward. A circumferential incision is made with the Bovie knife through the rectal mucosa and muscle at a level approximately 3 mm. proximal to the pectinate line. All bleeding points should be clamped and tied with 000 chromic catgut. The outer layer of the bowel is then stripped distally from the inner loop (Fig. 2).

The hernial sac is located anteriorly on the rectal wall and opened. The sliding character of the hernia then becomes apparent as the posterior peritoneal layer of the sac is seen to be the visceral peritoneum of the rectum. A large redundant loop of rectum and sigmoid colon, with its attached mesentery, usually falls through the opened hernial sac into the wound (Fig. 3).

The point of section which will permit removal of all redundant large bowel is then selected. The mesosigmoid and its vessels are clamped, divided and secured at this level, and the bowel is prepared for resection and anastomosis without redundancy or tension. The cul-de-sac hernia is then obliterated by a continuous suture of 00 chromic catgut which sutures the neck of the sac to the visceral peritoneum of the sigmoid at a high level. The resultant suture line has the shape of an inverted "Y."

The bowel is now retracted posteriorly, and the levator ani muscles are exposed on both sides. The edges of the levator ani muscles and their enclosing fasciae are approximated in the midline in front of the bowel with three or four interrupted sutures of 0 chromic catgut (Fig. 4), thus eliminating the large defect in the pelvic diaphragm. This produces a strong musculofascial support beneath the peritoneal closure. With the redundant exteriorized bowel held under gentle traction, it is divided into two lateral halves by an anterior and posterior incision made up to the point previously prepared for resection and anastomosis.

Two Mayo mattress sutures of 00 chromic catgut are now placed anteriorly and posteriorly to unite the bowel to the

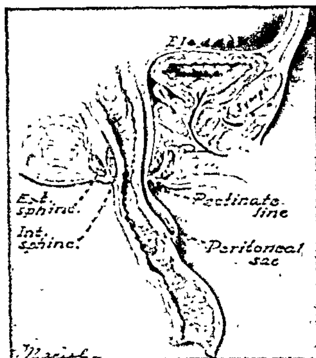


Fig. 2. Half-tone drawing of prolapse after circumferential incision of outer loop and conversion into a single loop of redundant rectum and rectosigmoid. Note relationship of hernial sac to anterior wall of rectosigmoid

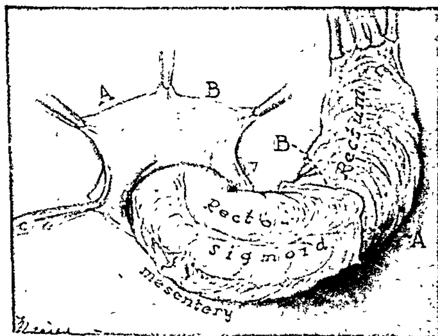


Fig. 3. Illustration of opened hernial sac and elongated loop of rectosigmoid, mesentery and rectum falling through hernial orifice.

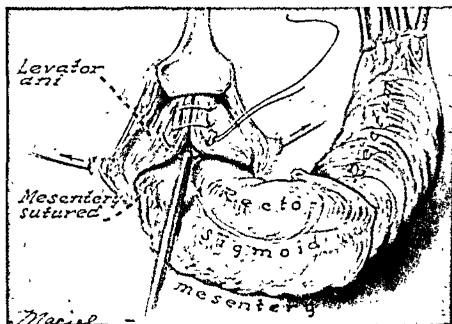


Fig. 4. Demonstration of closure of levator muscles anterior to the rectosigmoid after ligation of the hernial sac.

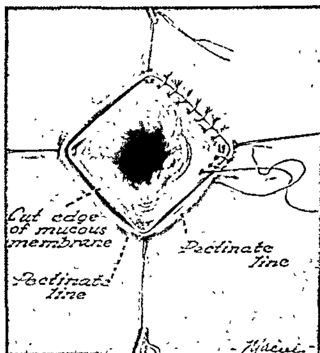


Fig. 5. Completion of anastomosis of divided bowel to mucous membrane at pectinate line.

mucous membrane 3 mm. above the pectinate line. The bowel is next transected progressively in quadrants, and the anastomosis is completed using interrupted sutures of 000 chromic catgut on swedged needles (Fig. 5). This method compensates for the disparity between the narrower lumen of the bowel and the larger diameter of the overstretched anal ring. Drainage of the perirectal space is unnecessary.

Postoperative Care

Postoperatively, antibiotic therapy is recommended, giving aqueous penicillin in doses of 100,000 to 400,000 units intramuscularly every four hours, with or without streptomycin 1 gram daily, for a period of five days. A liquid diet is usually tolerated initially, and is followed by a low residue diet after the second or third day. Mineral oil in doses of 1 ounce twice daily is of benefit in softening the stool and easing defecation. Ambulation is started on the day following operation, but digital examination of the anal rectal area is not permitted until the tenth postoperative day. Other authors have emphasized the need of preoperative and postoperative active exercises of the sphincter muscles, but their value is questionable, and we have found them unnecessary in our patients.

Advantages of This One-Stage Perineal Procedure

A well developed true prolapse of the rectum has many anatomic factors which demand recognition and correction if the repair is to be successful and permanent. Most important is the full understanding that the lesion is a sliding hernia of the cul-de-sac which passes through the weakened pelvic diaphragm, invaginating the anterior rectal wall and descending through the anal canal. As in all hernioplasties, good surgical practice necessitates the total ablation of the peritoneal sac and plastic repair of the structural defect through which it extends. Our procedure fulfills these requirements and has the following advantages:

1. Its perineal approach permits accurate diagnosis and correction of any structural defects encountered. When one plans operative repair of a rectal prolapse, he cannot determine with certainty preoperatively the type of prolapse or the

anatomic variation responsible for the lesion. The perineal approach described allows visibility and direct access not obtainable by the abdominal route.

2. The operation is a one-stage procedure.

3. Its approach is perineal, rather than transabdominal, and for this reason is better tolerated in the poor-risk aged or debilitated patients. It also requires less extensive anesthesia and produces relatively little operative trauma.

4. The procedure is definitive, being designed to eliminate the sliding hernia and to repair the hernial defect through the following steps:

(a) Excision and high ligation of the herniated cul-de-sac.
(b) Resection of the redundant bowel and its heavy elongated mesentery. This reduces the mobility of the bowel and its tendency to intussusception.
(c) Accurate plastic repair of the defect in the pelvic diaphragm under direct vision and easy accessibility.
(d) Accurate revision of the size of outlet in the pelvic diaphragm for passage of the large intestine.
(e) Accurate anastomosis of the margin of the rectosigmoid colon to the distal rectal mucosal cuff without tension.
(f) Correction of the disparity between the diameter of the dilated anal ring and that of the narrow proximal sigmoid.

5. The morbidity accompanying this operation has been remarkably low in our experience of 43 consecutive cases.

6. There has been no operative or postoperative mortality.

7. Unnecessary procedures such as colopexy, perirectal scarification, and difficult obliteration of the cul-de-sac by suture are eliminated.

Disadvantages

The possible disadvantages of this procedure which we have encountered include the following:

1. The procedure requires resection of the rectum along with the crypts and columns of Morgagni.

2. A period of fecal incontinence usually exists for twenty-one to thirty days. At the end of this period, the patients begin to acquire continence which is usually complete within two to

three months. The sensation of the need to defecate is likewise acquired. Sphincteric action is taken over by the levator ani muscles. In some instances, there is a return of function of the external sphincteric muscle.

Summary

The one-stage perineal operation for prolapse of the rectum as described above permits accurate determination of the type of prolapse in the individual case, as well as the anatomic variations responsible for the lesion, direct approach to the hernial sac and the defect in the pelvic diaphragm, operative obliteration of the hernia, resection of the redundant bowel and its mesentery, and plastic repair of the hernial defect. Cure of the prolapse has been accomplished with a remarkably low mortality and low morbidity in a group of patients characteristically debilitated by senility or associated disease. This operation has been definitive and the results obtained during the past eight years in 43 consecutive cases have been remarkable. The procedure is recommended for serious consideration and trial.

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An Evaluation of the Orr Suspension Operation for Rectal Prolapse

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Since the early writings of Ambröise Paré on "The Falling Down of The Fundament," prolapse of the rectum has attracted considerable surgical attention and has been the subject of numerous publications in medical literature. Although prolapse of the rectal mucosa is encountered frequently, true prolapse of the rectum is not a common condition. When called upon to treat a patient having this affliction, the surgeon may select from a number of operative procedures to be found in reference lists on operative surgery. Such was the case when Dr. T. G. Orr first presented yet another operation designed to correct prolapse of the rectum before the American Surgical Association in 1947, and such is the case today except that a few additional procedures have been added to the list.

At the time of his original presentation, Dr. Orr had four patients on whom this procedure had been done with follow-up periods ranging from six years to three months. In order to assess further the efficacy of this procedure, follow-up data on all patients who have had the Orr operation for rectal prolapse at the University of Kansas Medical Center have been compiled and are here presented, together with similar data on 23 cases reported in the literature and by personal communication.

Rectal Prolapse Defined

To avoid confusion between true rectal prolapse and various degrees of prolapsed rectal mucosa, usually accompanied by severe hemorrhoids, the term procidentia may be used to

designate the former condition although this invites further confusion because of the more common usage of this term as applied to severe uterine prolapse. Designations into numerical types or degrees of prolapse to distinguish between true prolapse and simple prolapsed mucosa are likewise unsatisfactory since the two conditions present entirely different problems in management.

Complete rectal prolapse is in reality a sliding hernia and as such resembles the common type of herniation occurring at the opposite entrance of the gastrointestinal tract into the peritoneal cavity, the esophageal hiatus. In true prolapse all layers of the rectal wall protrude through the relaxed and dilated anal sphincter. The anterior rectal wall is covered with peritoneum (the posterior portion of the cul-de-sac) and, as the prolapse descends, the bowel wall folds upon itself producing a peritoneum-lined hernial sac between the two layers. The posterior rectal wall has no peritoneal covering and is comparatively more fixed, with a resultant limitation of the extent of prolapse. Thus in true prolapse the bowel orifice representing the apex of the protruding bowel is always in an eccentric position with the opening pointing posteriorly.

Principles of the Orr Procedure

Although a number of causative factors have been implicated as contributing to the production of prolapse, the presence of an abnormally deep cul-de-sac, combined with an abnormally attached rectosigmoid with a very long mesentery, seems to be of the most importance. The Orr operation is designed to correct these two abnormalities. Redundancy of the bowel is corrected by suspending the rectosigmoid from the fascia above the sacral promontory with two strips of fascia lata. The deep cul-de-sac is then completely obliterated by rows of interrupted sutures. This procedure, requiring little disturbance of normal tissues and involving no resection of bowel, can be easily and quickly completed with very little hazard to the patient. In contrast, most of the recent publications on this subject recommend removal of bowel, either by resection of the redundant sigmoid and upper rectum through an abdominal approach or by resection of the protruded portion of the rec-

tum using the perineal approach, or by a combination of the two.

When the follow-up results of the Orr operation are compared with those reported for the various resection-type procedures, there would seem to be little justification for using the resection procedures with the increased hazard of peritoneal contamination and trauma associated with resection of the bowel.

Technique of Operation

Two strips of fascia 1 to 2 cm. in width and 10 to 12 cm. in length are removed from the fascia lata of the thigh. This can be done directly or by use of a special fascia stripper (Fig. 1).

With the patient in the Trendelenburg position, a left paramedian incision is made from the pubis to approximately 2 cm. above the umbilicus. The contents of the upper abdomen are packed away and the lower sigmoid is lifted into the

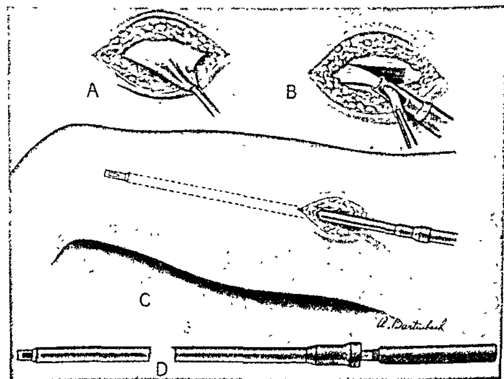


Fig. 1. Use of the Masson fascia stripper to obtain strips of fascia lata. (Figs. 1 to 4 from Higgins and Orr, Orr's Operations of General Surgery, 3rd Edition.)

wound (Fig. 2). A tape may be passed around the bowel for traction purposes.

The fascia above the promontory of the sacrum is now exposed through an inverted "T" incision in the peritoneum (Fig. 3). The two strips of fascia are next sutured along each side of the rectum with a double row of interrupted sutures, placing the lower end of the fascial strips just above the lowest part of the peritoneal reflection. The fascial strip on the left is then passed through a small incision made in the mesentery of the sigmoid. While the rectum and lower sigmoid are held suspended, the upper portions of the fascial strips are sutured to the dense fascia over the sacral promontory with interrupted silk sutures. It is important that the rectum be suspended out of the lower pelvis as far as possible before securing the fascial

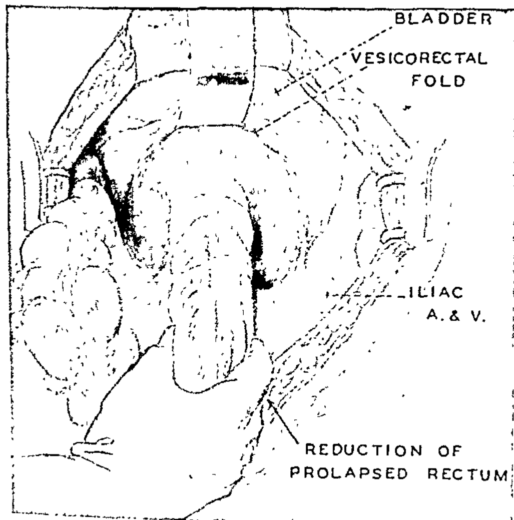


Fig. 2. Operative field following reduction of rectal prolapse preliminary to suspension showing area anatomy.

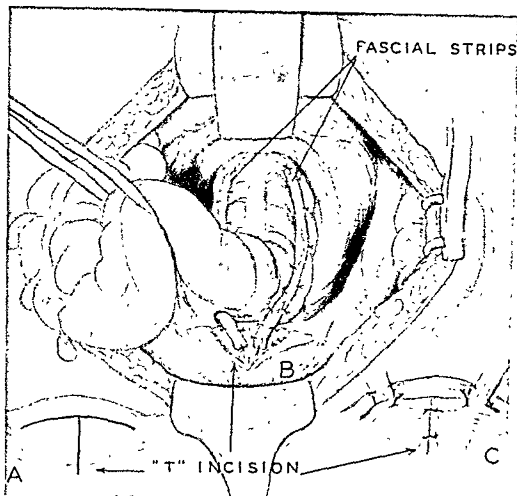


Fig 3. Strips of fascia have been sutured to the sides of the rectum and to the fascia overlying the sacral promontory. The fascial strip on the left is passed through the mesentery. *A* and *C* show the T-shaped incision in the peritoneum over the sacral promontory and its closure after securing the fascial strips in place. It is important to reduce the prolapse completely from the deepest portion of the pelvis before securing the fascial strips to the sacral fascia.

strips. The cul-de-sac is next obliterated by placing rows of interrupted silk suture transversely across the pelvis. The peritoneum immediately anterior to the rectum is sutured to the rectal wall as the transverse rows of sutures are being placed. Lateral folds of the pelvic peritoneum are now sutured to the rectal wall on each side to cover the fascial strips (Fig. 4). The abdominal incision is then closed.

Avoidance of constipation in the early postoperative period is important. In most of these patients, and particularly in those who have had prolapse for a long time, the anal sphincter muscles have been severely stretched with a resultant loss of

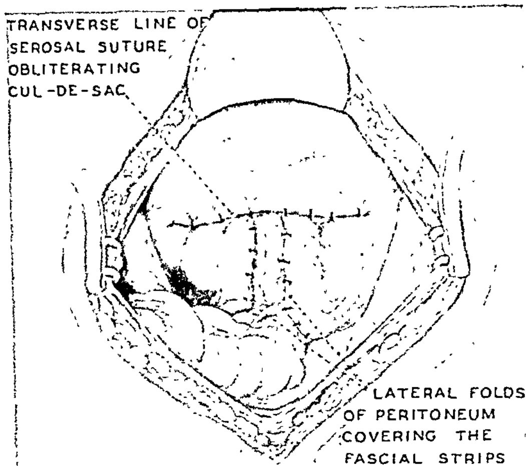


Fig. 4. Completed operation showing obliteration of the cul-de-sac by transverse rows of interrupted sutures and covering of fascial strips by folds of peritoneum.

sphincter tone. For this reason the patient should be instructed in sphincter-tightening exercises to be carried out in the post-operative period.

Long-Term Follow-up Results

In an effort to evaluate the long-term follow-up results of the Orr suspension operation, the records of all patients who had the operation at the University of Kansas Medical Center were reviewed. To this was added one patient operated upon at the Kansas City Veterans Hospital, for a total of 12 cases. All of these patients had true rectal prolapse. An additional 23 cases were obtained from the literature and by personal communication, making a total of 35 cases available for study.

Results of the survey are given in Tables 1 and 2. As indicated in Table 1, the period of follow-up of patients operated

TABLE 1. SUMMARY OF FOLLOW-UP RESULTS OF THE ORR SUSPENSION OPERATION (UNIVERSITY OF KANSAS MEDICAL CENTER CASES)

Patient	*Sex*	*Age*	*Date of Operation*	*Date Last Follow-up*	*Remarks*
F. H.	M	36	Feb '41	Jan. '47	No recurrence of prolapse. Moderate constipation.
J. A	M	68	Mar '44	Mar. '47	No recurrence.
J. J.	M	33	Nov. '45	Sept. '58	No recurrence. Excellent result
E. B	F	66	Jan '47	1954	No recurrence. Died, heart disease 1954.
A. D.	M	34	Oct. '50	Mar. '58	No recurrence of prolapse. Small hemorrhoids.
M. B	F	46	Nov. '50	Aug '58	Resection of redundant rectal mucosa, 1956. Well at present.
C. J.	M	27	Feb. '54	July '58	No recurrence
V. S	F	34	June '54	Aug '58	No recurrence
D. S.	F	7 mos	Jan. '55	May '58	Patient had exstrophy of bladder also. No recurrence of prolapse. Ureters transplanted and exstrophy closed 1957.
J. H	F	59	Feb '55	Aug. '58	No recurrence
K. R.	F	3	Apr. '56	July '58	Had imperforate anus at birth, 1952. Prolapse repaired 1956, followed by resection of redundant mucosa 1 wk. later. No recurrence—some trouble with incontinence
R D.	M	61	Aug. '57	Sept. '58	No recurrence.

upon at the University Medical Center varies from thirteen months to thirteen years. In these there has been no instance of recurrence of the prolapse. One patient developed a redundancy of the rectal mucosa which was treated by simple excision six years after the suspension operation. A second patient, an infant aged three years who had an imperforate anus at birth, required simple excision of redundant rectal mucosa one week after the suspension procedure. This patient, now five years old, has slight difficulty with fecal incontinence although the sphincter tone appears adequate on examination. None of the other patients reports any difficulty with fecal incontinence.

TABLE 2. SUMMARY OF FOLLOW-UP RESULTS OF THE ORR SUSPENSION OPERATION (CASES REPORTED IN THE LITERATURE OR BY PERSONAL COMMUNICATION)

Authors	*Number of Cases*	*Follow-up Periods*	*Postoperative Status*
Levy and Johnson	2	6 years	Recurrence in one case 3 yrs. after operation
Moreno and Villamil	3	1 to 2 years	No recurrences
Floyd and Alley	2	3 years	No recurrences
Burger	1	1½ years	No recurrences
Gibbs	1	8 years	No recurrence
Loygue and Cerbonnet	14	3 months to 4 years	No recurrences

A summary of the results obtained by others and reported in the literature and by personal communication is found in Table 2. There was only one recurrence in these 23 cases, that in a patient reported by Levy and Johnson. These authors reported a bulging of the perineum in this patient two years after operation, and the prolapse recurred a year later. Levy and Johnson attribute this recurrence to failure to suspend the rectum completely from the pelvic floor prior to suturing the fascial strips to the presacral fascia. Of the 14 cases reported by Loygue and Cerbonnet, only half have been followed sufficiently long to provide adequate information concerning recurrence. Although these authors modify slightly the technique described by Dr. Orr, the general principle of fascial suspension is followed.

Comment

The follow-up results compiled in Tables 1 and 2 require little comment. The one instance of recurrence reported in the 35 cases is attributed by the authors to faulty technique. It is possible that there may in time be additional recurrences, but both in number of cases and length of follow-up this series compares favorably with others of patients having any of the numerous other operative procedures described for this condition.

It is probable that no single procedure is suitable in all

cases of rectal prolapse. In view of its simplicity, as well as its effectiveness as indicated by the low incidence of recurrence, the Orr suspension operation merits further application in the treatment of rectal prolapse.

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Index of Contributors

Page numbers in *italic* indicate introductory material.

Ackerman, Lauren V, 37
Allbritten, Frank F., Jr, 169
Altemeier, William A., 313

Baker, Joel W., 101
Balch, Henry H., 279
Barker, Wiley F., 238
Berne, Clarence J., 9
Braasch, John W., 140
Breed, Ernest S., 269

Cantor, Meyer O., 197
Cattell, Richard B., 140
Clayman, Charles B., 5
Colcock, Bentley P, 45

de Takats, Geza, 243
Deterling, Ralph A., Jr., 224
Doubilet, Henry, 121

Edwards, Leonard W., 126
Effler, Donald B., *70*
Ellison, Edwin H., *55*; *185*; 187; *209*

Ferris, Deward O., 110
Frantz, Virginia Kneeland, 159
Friesen, Stanley R., *1*; *135*; *157*; *253*, *295*; *311*

Greene, Laurence, Jr., 313
Growdon, James H, *74*

Haagensen, C D, 175
Herrington, J. Lynwood, Jr., 15; 126
Hermann, Louis G., 211
Higgins, George A., 322

Keirle, Alfred, 313
Kirsner, Joseph B., 5

Large, Alfred M, 154
Lawrence, G. Hugh, 101
Lempke, Robert E., 147

McKittrick, Leland S., 297
Mikkelsen, William P., 9

Miller, Don R , 255
Mulholland, John H., *35; 83; 99; 119,* 137; *145; 173; 267*

Nissen, Rudolf, 57

Palmer, Walter L., 5
Poth, Edgar J , 301

Raffman, Richard A., 159

Rhoads, Jonathan E., 85
Ripstein, Charles B , 42

Schilling, John A., 262
Schloerb, Paul R., 287
Scott, H. William, Jr., 15
Spratt, John S., Jr., 37

Walker, John H., 101
Wangensteen, Owen H., 25
Williams, Roger D , 92

Index of Subjects

ABDOMINAL repair of hiatal hernia, 74–81. See also under *Hiatal hernia.*
Abscess, intra-abdominal, in intestinal obstruction as indication for use of long decompression tube, 200
Allison's operation, for hiatal hernia, principles of, 75
  for sliding hiatal hernia, shortcomings of, 59
Ampulla of Vater, patency of, complete, importance and methods of establishing before primary closure of common duct wound, 129
Anastomosis, end-to-end, in bile duct strictures, 140–143
Anesthesia for early operation in intestinal obstruction, 193
Antibiotics, in preoperative preparation of colon, 301–310
    choice of agent, 301
    desirable properties of, 302
    evaluation of, 305–308
    hazards and methods of meeting them, 304
    indications for, 303
  in small bowel obstruction, 191
Anticoagulants, in thrombo-embolism, 262–266
  use of, after vena caval ligation for thrombo-embolism, 257
Anticoagulation, role of, in patients with blood vessel transplants, 233
Antiseptics, intestinal, preoperative, 301–310
Antiseptics, intestinal, preoperative, desirable properties of, 302
    indications for, 303
Antrectomy with bilateral vagotomy and Schoemaker-Billroth I end-to-end gastroduodenostomy for duodenal ulcer, rationale, technique, and results, 15–24
Antrum, role of, in duodenal physiology, 10
Aorto-iliac obstructions, thrombo-endarterectomy for, indications and results, 239
Aorto-iliac and femoral obstructions, thrombo-endarterectomy for, indications and results, 240
Arlidin with prostigmine after sympathectomy for occlusive vascular disease, 249
Arterial circulation, collateral. See under *Circulation.*
Arterial grafts, homologous, preserved, in arterial insufficiency of lower extremities, 225
Arterial insufficiency of lower extremities, 209–252
    arterial grafts in, homologous, preserved, 225
    atheromatosis of, treatment, 248
    avoidance of exposure to cold in, 218
      of infection in, 218
      of local heat in, 217
    blood vessel replacement in, evaluation of, 224–237

Arterial insufficiency of lower extremities, collateral arterial circulation in, importance of maintaining, 212, 221
complications, control of factors causing, 217
conservative management, 211–223
cooperation of patient in treatment, enlisting, 214
exercises in, 216
general measures of therapeutic value, 214
implantation techniques, evaluation of, 231
lumbar sympathectomy in, 222, 235, 242, 243–252
arguments against, 250
background of, 243
benefits of, 243–248
preliminary testing for, 244
control of blood cholesterol after, 248
drug therapy after, 249
effects on intermittent claudication, 246–249
exercise after, 248
prophylactic, 249
tests indicating usefulness of, 244
management of, 209–252
need for accurate case selection, 248, 251
optimum resting level of limb in, 216
passive vascular exercises in, 222
practical therapy, basis of, 211
prevention of trauma in, 215
skin care in, 214

Arterial insufficiency of lower extremities, surgical treatment, aggressive, disadvantages of, 211
synthetic prostheses in, 227–234
anticoagulation with, role of, 233
carcinogenic potentials, 230
complications, 230
materials, 228
thrombo-endarterectomy for, 234, 238–242
indications and results, 239–242
rationale and advantages of, 238, 239
tobacco prohibited in, 215
vasodilatation in, methods of producing, 218
vein grafts in, autogenous, 224
Atheromatosis in occlusive vascular disease, treatment, 248

Bile duct(s), common See *Common duct*
irrigation of, at operation, 115
strictures, repair of, end-to-end, 140–143
evaluation of procedures, 140
from standpoint of recurrence, 141
of technical difficulty, 140
secondary, requisites of, 138
Biopsy of regional lymph nodes in selection of cases for radical mastectomy in breast cancer, 180–182
Blood, whole, transfusions of, in small bowel obstruction, 191
Blood vessel replacement, evaluation of, in arterial insufficiency of lower extremities, 224

Bowel, preoperative preparation of, 295–310
with antibiotics, 301–310
without antibiotics, 295–300
Breast, carcinoma of, early cases, treatment, need for comparative studies in, 182
status of irradiation in, 183
radical mastectomy for, results in staged series of cases, 179
selection of cases, 179
regional lymph node biopsy method, 180–182
versus irradiation, 175–183
staging, clinical method of, 177
treatment, absolute survival rates as measure of achievement, 175
choice of, 173–183
Brigham-Kolff machine for artificial hemodialysis, 281
Bypass implantation techniques in occlusive arterial disease, evaluation of, 231

Calcium requirements in acute renal failure, 275
Calculi, common duct, detection of, 99–117. See also *Common duct stones.*
Carcinoma of breast, early cases, treatment, need for comparative studies in, 182
status of irradiation in, 183
radical mastectomy for, results in staged series of cases, 179
selection of cases, 179
regional lymph node biopsy method, 180–182
Carcinoma of breast, staging, clinical method of, 177
treatment, absolute survival rates as measure of achievement, 175
choice of, 173–183
radical mastectomy versus irradiation, 175–183
of colon, congenital polyposis and, association of, 48
new, time required to reach 1.5 cm., 40
polyps and, age-adjusted incidences in standard population, 38
frequency of association, 47
relationship, 45–53
ulcerative colitis and, association of, 49
of head of pancreas, 83–97
choice of operation in, factors influencing, 85, 92
operative risk in, 94
origin and extent of tumor, 92
palliative procedures for, 92–97
factors influencing choice, 92
results from, 95
radical duodenopancreatectomy for, 85–91
factors influencing choice of, 85
operative steps, 87
results and their evaluation, 88
pancreatoduodenal, 83–97. See also *Carcinoma of head of pancreas.*
Catgut, use of, in ligation of inferior vena cava for thrombo-embolism, 257
Cholangiography, operative, 101–109, 116
applications and rationale, 102
objections answered, 105
prerequisites for success, 101

Cholangiography, operative, results obtained, 107
technique of, 103
Cholecystectomy, *cholangiography* at time of, 102, 103, 108, 116
for cholelithiasis, cholangiography at, value of, 108
exploration of common duct at, 110
Cholecystitis after sphincterotomy with gallbladder left in place, *152*, *154*, *155*
Cholecystography, oral, after sphincterotomy, in study of gallbladder function, 150
Choledochitis after sphincterotomy with gallbladder left in place, 152, 154, 155
Choledochoduodenostomy in carcinoma of head of pancreas, 95
Choledochojejunostomy, in carcinoma of head of pancreas, 95
repair of common duct stricture by, 137–139
Choledocholithiasis See *Common duct stones*
Choledochorrhaphy, primary, 126–*134*
Choledochotomy, at time of cholecystectomy, cholangiography in determining need for, 108
for stone removal, technique of, 112
removal of T-tube after, proper time for, 116
Cholelithiasis, after sphincterotomy with gallbladder left in place, 155
cholecystectomy for, exploration of common duct at, 110
value of cholangiography at, 108
Cholesterol, blood, control of, in arterial insufficiency of lower extremities, 248
Circulation, arterial, collateral, in arterial insufficiency of lower extremities, maintaining or enhancing, 212–221
Claudication, intermittent, effects of sympathectomy on, 246–249
Cold, exposure to, avoidance of, in *arterial insufficiency of lower extremities*, 218
Colectomy, radical, for polyps of colon, 42–44
Colitis, ulcerative, carcinoma of colon and, association of, 49
Collateral circulation. See *Circulation.*
Colon, carcinoma of, *congenital* polyposis and, association of, 48
new, time required to reach 1 5 cm., 40
polyps and, age-adjusted incidences in standard population, 38
frequency of association, *47*
relationship, 45–53
ulcerative colitis and, association of, 49
polyposis of, congenital, association of cancer with, 48
polyps of, 35–53
cancer and, age-adjusted incidences in standard population, 38
frequency of association, 47
relationship, 45–53
clinical and microscopic appearance, in determining malignant potential, 50
distribution, similarity to that *of cancer, 46*
frequency of multiple occurrence, 46
treatment, as benign lesions, 37–41
as precancerous lesions, 42–44, 45–53
radical colectomy in, 42–44
when beyond reach of the sigmoidoscope, 38
when within reach of sigmoidoscope, 37
preoperative preparation of, 295–310

Colon, preoperative preparation of, with antibiotics, 301–310
choice of agent, 301
desirable properties of agent, 302
evaluation of, 305–308
hazards and methods of meeting them, 304
in absence of obstruction, 303
in complete obstruction, 303
in partial obstruction, 303
indications for, 303
with kanamycin, 301
with neomycin and phthalylsulfathiazole, 302–305
with phthalylsulfathiazole, 298, 301
with succinylsulfathiazole, 298, 301
with sulfaguanidine, 301
without antibiotics, 297–300
in complete obstruction, 299
in minimal obstruction, 298
in partial obstruction, 299
Common duct, stones, detection of, 99–117
by operative cholangiography, 101–109, 116. See also *Cholangiography, operative.*
by operative exploration, 110–117
indications for, 111
technical considerations, 112–117
removal of, importance of scoop, 112, 113
technique, 112
use of dilators before closing duct, 113
stricture, formation of, factors leading to, 137
repair of, 135–143
by choledochojejunostomy, 137–139
Common duct, stricture, repair of, end-to-end, 140–143
advantages of, 140, 141
contraindications to, 142
evaluation of procedures, 140
from standpoint of recurrence, 141
of technical difficulty, 140
wound, management of, 119–134
by primary closure, 126–134
clinical experience with, 128
historical aspects, 126
importance and methods of establishing complete patency of ampulla of Vater before closure, 129
reasons for advocating, 127
results compared with those of T-tube drainage, 128
technique of, 130
versus T-tube drainage, 123
by T-tube drainage, 121–125
indications for, 132
precautions prior to insertion of tube, 121
results compared with those of primary closure, 128
value of, 122
versus primary closure, 123

DECOMPRESSION, intestinal. See *Intestinal decompression.*
Dialysis, artificial, in acute renal failure, 279–286

Dialysis, intestinal, in acute renal failure, 290–293
peritoneal, in acute renal failure, 287–293
Diet in acute renal failure, 269–278
Dilatation, of ampulla of Vater before primary closure of common duct wound, 130
of sphincter of Oddi, 114
Dilators, filiform-guided, for sphincter of Oddi, 114, 115
Distention, inflammatory, in intestinal obstruction as indication for use of long decompression tube, 200
Drugs, vasodilator, efficacy of, in arterial insufficiency of lower extremities, 219
Duodenal ulcer, 1–33
bilateral vagotomy and antrectomy with Schoemaker-Billroth I end-to-end gastroduodenostomy for, rationale, technique, and results, 15–24
curative surgery, basic concepts, 11
medical treatment, roentgen irradiation of stomach as adjunct, methods and results, 5–8
segmental resection for, 25–33
indications, 26
rationale of, 26
technique and results, 27–32
vagotomy, pyloroplasty and supra-antral segmental resection for, 9–14
Duodenopancreatectomy, radical, for carcinoma of head of pancreas, indications, technique, and results, 85–91
Duodenum, importance of, in ulcer-curative surgery, 10

Edema following vena caval ligation, 257, 259
Electrolyte replacement therapy in acute renal failure, 274
Embolism, pulmonary, prevention of, by anticoagulants, 262–266
by inferior vena caval ligation, 255–261
Endarterectomy. See *Thrombo-endarterectomy.*
End-to-end implantation techniques in occlusive arterial disease, evaluation of, 231
End-to-end repair of bile duct strictures, 140–143
Epithelium, "buried," as cause of pilonidal sinus, fallacy of, 162
Esophageal hiatal hernia, repair of, 55–81. See also under *Hiatal hernia.*
Esophagitis, reflux, in hiatal hernia, as cause of symptoms, 58, 65
fundoplication for, 66, 67
Estradiol dipropionate as vasodilator in arterial insufficiency of lower extremities, 220
Estrogens, synthetic, as vasodilators in arterial insufficiency of lower extremities, 220
Exercise(s), after sympathectomy for arterial insufficiency of lower extremities, 248
graded, active, in arterial insufficiency of lower extremities, 216
passive vascular, in arterial insufficiency of lower extremities, 222
Exploration, operative, for detection of common duct stones, 110–117
Extremities, lower, arterial insufficiency of, management, 209–252

Fascia stripper, Masson, use of, 324
Fat emulsion, intravenously, in acute renal failure, 273
orally and by nasogastric tube, in acute renal failure, 270

Femoral and aorto-iliac obstructions, thrombo-endarterectomy for, indications and results, 240
Femoral thrombo-endarterectomy, indications and results, 241
Femoropopliteal thrombo-endarterectomy, indications and results, 241
Fluids, regulation of, in acute renal failure, 269–278
requirements of, in small bowel obstruction, 191
Fundoplication, addition of, to gastropexy for para-esophageal hernia, 65
for sliding hiatal hernia, 67, 68

GALLBLADDER, function of, after sphincterotomy, 147–153
cholecystographic studies, 150
manometric studies, 147–150
normal, management at sphincterotomy, 145–156
removal of, at time of sphincterotomy, 154–156
Gastric suction and early operation for small bowel obstruction, 187–196
versus intestinal decompression and delayed surgery, 185–208
Gastric ulcer, medical treatment, roentgen irradiation of stomach as adjunct, methods and results, 5–8
Gastroduodenostomy, end-to-end, with bilateral vagotomy and antrectomy for duodenal ulcer, rationale, technique, and results, 15–24
Gastropexy, for hiatal hernia, 57–69
Gastropexy, for para-esophageal hernia, addition of fundoplication, 65
historical perspective and rationale, 58
technique of, 63–65
for sliding hiatal hernia, addition of fundoplication, 68
historical perspective and rationale, 59
technique of, 60–63
Glucose in acute renal failure, by continuous drip into saphenous stump or vena cava, 272
insulin and heparin added to, 273
intravenously by simple infusion, 271
orally and by nasogastric tube, 270
testosterone propionate as adjunct to control potassium levels, 271
Grafts, arterial, homologous, preserved, in arterial insufficiency of lower extremities, 225
blood vessel, end-to-end versus bypass techniques, 231, 232
synthetic, in arterial insufficiency of lower extremities, 227–234
vein, autogenous, in arterial insufficiency of lower extremities, 224

HAIR, implanted, as cause of pilonidal sinus, 165
treatment based on, 165, 166
Heat, local, avoidance of, in arterial insufficiency of lower extremities, 217
Hemodialysis, artificial, Brigham-Kolff machine for, 281
in acute renal failure, 279–286
indications for, 282

Hemodialysis, artificial, in acute renal failure, problem of associated tissue damage, 283
of infection, 284
results with, 284
timing of, 283
stationary twin-coil dialyzing tube for, 281, 282
Heparin, addition of, to glucose drip in acute renal failure, 273
use of, with blood vessel transplants, 233
Hepaticoduodenostomy versus end-to-end repair in biliary stricture, 140
Hernia, hiatal, esophageal, repair of, 55–81. See also under *Hiatal hernia*
para-esophageal. See under *Hiatal hernia*
Hiatal hernia, Allison's operation for, principles of, 75
classification, 70
gastropexy for, 57–69
para-esophageal, gastropexy for, fundoplication added to, 65
historical perspective and rationale, 58
technique of, 63–65
pulsion type, 70
repair of, 55–81
abdominal, 74–81
advantages afforded by, 77
contraindications to, 76
by fixation to abdominal wall, 57–69
choice of surgical approach, 76
indications for, 74
transthoracic, advantages afforded by, 72
principles and techniques, 70–73
sliding, Allison's operation for, shortcomings of, 59
gastropexy for, fundoplication added to, 67, 68
Hiatal hernia, sliding, gastropexy for, historical perspective and rationale, 59
technique of, 60–63
reflux esophagitis as cause of symptoms, 58
traction type, 71

Ileus, atonic, in intestinal obstruction, as indication for use of long decompression tube, 200
Implantation techniques in arterial insufficiency of lower extremities, evaluation of, 231
Impotency following bilateral lumbar sympathectomy, 250
Incision for early operation in intestinal obstruction, 194
Infection, avoidance of, in arterial insufficiency of lower extremities, 218
in acute renal failure, artificial hemodialysis in presence of, 284
with synthetic blood vessel replacements, 231
Insulin, addition of, to glucose drip in acute renal failure, 273
Intestinal antiseptics, preoperative, 301–310
desirable properties of, 302
indications for, 303
Intestinal decompression and delayed surgery in small bowel obstruction, 197–208
indications for, 199
versus gastric suction and early operation, 185–208
Intestinal obstruction. See also under *Intestines, small, obstruction of.*
colon preparation in presence of, 298, 299, 303

Intestinal perfusion in acute renal failure, 290–293
effects of, 292
indications and contra-indications, 291, 292
methods, 290
results with, 292
Intestinal surgery, preparation of patient and of bowel for, 295–310
with antibiotics, 301–310
without antibiotics, 295–300
Intestines, small, obstruction of, antibiotics in, 191
atonic ileus in, as indication for use of long decompression tube, 200
diagnosis, 193, 198
x-ray, 192
early operation in, importance of, 188
etiology, 187
fluid requirements in, 191
gastric suction and early operation for, 187–196
plan of management, 189–191
surgical considerations, 193
versus intestinal decompression and delayed surgery in, 185–208
inflammatory distention in, as indication for use of long decompression tube, 200
mechanical, as indication for use of long decompression tube, 201
strangulation in, recognition of, 199
use of long decompression tube in, 197–208
indications for, 199
whole blood transfusions in, 191
Intubation, intestinal. See *Intestinal decompression.*
Irradiation, for carcinoma of breast, early cases, status of, 183
versus radical mastectomy, 175–183
of stomach as adjunct to medical treatment of peptic ulcer, methods and results, 5–8
Irrigation of bile ducts at operation, 115

KANAMYCIN in preoperative preparation of colon, 301
Kidney, artificial, Brigham-Kolff machine, 281
in acute renal failure, 279–286
indications for, 282
problem of associated tissue damage, 283
problem of infection, 284
results with, 284
timing of use of, 283
stationary twin-coil dialyzing tube, 281, 282
failure, acute, 267–295. See also *Renal failure, acute.*

LEG, sequelae, factors responsible for, after vena caval ligation, 259
Ligation of inferior vena cava for thrombo-embolism, 255–261
Lipomul in acute renal failure, 273
Lymph nodes, regional, biopsy of, in selection of cases for radical mastectomy in breast cancer, 180–182

MALPOSITION cardiofundal with severe reflux esophagitis, fundoplication for, 67

Manometric studies of gallbladder function after sphincterotomy, 147–150
Masson fascia stripper, use of, to obtain strips of fascia lata, 324
Mastectomy, radical, for carcinoma of breast, results in staged series of cases, 179
selection of cases, 179
regional lymph node biopsy method, 180–182
versus irradiation, 175–183
Metabolites as vasodilators in arterial insufficiency of lower extremities, 219
Miller-Abbott tube, use of, in intestinal obstruction, 186, 188, 197–208

Nasogastric feedings in acute renal failure, 270
Neomycin plus phthalylsulfathiazole in preoperative preparation of colon, 302–305
Nerve blocks, regional, as test of usefulness of sympathectomy in vascular occlusions, 245
Neuralgia, postsympathectomy, 250
Nilevar in acute renal failure, 272
Norethandrolone in acute renal failure, 272
Nylidrin (Arlidin) with prostigmine after sympathectomy for occlusive vascular disease, 249

Obstruction, small bowel See *Intestines, small, obstruction of.*
Occlusive vascular disease See *Arterial insufficiency.*
Oliguria. See *Renal failure, acute.*
Orr suspension operation for prolapse of rectum, 322–330
Orr suspension operation for prolapse of rectum, long-term follow-up results, 327–329
principles of, 323
technique of, 324

Pancreas, head, carcinoma of, 83–97
choice of operation in, factors influencing, 85, 92
operative risk in, 94
origin and extent of tumor, 92
palliative procedures for, 92–97
factors influencing choice, 92
results from, 95
radical duodenopancreatectomy for, 85–91
factors influencing choice of, 85
operative steps, 87
results and their evaluation, 88
Pancreatoduodenal carcinoma, treatment of, 83–97
by palliative procedures, 92–97
by radical duodenopancreatectomy, 85–91
Para-esophageal hernia, gastropexy for, fundoplication added to, 65
historical perspective and rationale, 58
technique of, 63–65
Paravertebral sympathetic block as test of usefulness of sympathectomy in vascular occlusions, 244
Patient, preparation of, for intestinal surgery, 297
for one-stage perineal operation for rectal prolapse, 315

Peptic ulcer, 1–33
bilateral vagotomy and antrectomy with Schoemaker-Billroth I end-to-end gastroduodenostomy for, rationale, technique and results, 15–24
medical treatment, roentgen irradiation of stomach as adjunct, methods and results, 5–8
operation for, criteria of acceptability, 26
segmental resection for, 25–33
indications, 26
rationale of, 26
technique and results, 27–32
vagotomy, pyloroplasty, and supra-antral segmental resection for, 9–14
Perfusion, intestinal, in acute renal failure, 290–293
Perineal operation, one-stage, for prolapse of rectum, 313–321
Peritoneal dialysis in acute renal failure, 287–293
effects of, 290
indications and contraindications, 289
results with, 292
technique, 288
Peritonitis in intestinal obstruction as indication for use of long decompression tube, 200
Phlebothrombosis, 253–266
anticoagulants in, 262–266
etiology, natural history, and course, 262
inferior vena caval ligation in, 255–261
prophylactic and therapeutic measures, 263
Phthalylsulfathiazole, in preoperative preparation of colon, 298, 301
plus neomycin in preoperative preparation of colon, 302–305
Pilonidal sinus, acquired origin, evidence that favors, 161
appearance of, after puberty, 160
"buried epithelium" in, fallacy of, 162
congenital origin, 159
evidence against, 160
implanted hair as cause, 165
treatment based on, 165, 166
pathogenesis of, 157–171
re-evaluation, 159–168
preventive measures, 166
treatment of, 157–171
preventive, 166
selective, *169–171*
surgical considerations, 170
Polyposis of colon, congenital, association of cancer with, 48
Polyps of colon, 35–53
*cancer and, age-adjusted inci*dences in standard population, 38
frequency of association, 47
relationship, 45–53
clinical and microscopic appearance of, in determining malignant potential, 50
distribution, similarity to that of cancer, 46
frequency of multiple occurrence, 46
treatment of, as benign lesions, 37–41
as precancerous lesions, 42–44, 45–53
radical colectomy in, 42–44
when beyond reach of sigmoidoscope, 38
when within reach of sigmoidoscope, 37
Potassium, levels, control of, in acute renal failure by addition of testosterone to intravenous *glucose, 271*
requirements, in acute renal failure, 276

Preoperative preparation, of colon, 295–310
with antibiotics, 301–310
without antibiotics, 295–300
of patient, for intestinal surgery, 297
for one-stage perineal operation for rectal prolapse, 315
Pressures, venous, before and after vena caval ligation, 256
Prolapse of rectum, 311–330
classification, 313
definition of, 322
one-stage perineal operation for, 313–321
advantages and disadvantages, 319, 320
postoperative care, 319
preparation of patient, 315
techniques, 316
Orr suspension operation for, 322–330
long-term follow-up results, 327–329
principles of, 323
technique of, 324
true, problem in, 314
Prostheses, synthetic, in arterial insufficiency of lower extremities, 227–234
carcinogenic potentials, 230
complications, 230
materials, 228
Prostigmine with nylidrin (Arlidin) after sympathectomy for occlusive vascular disease, 249
Prothrombin-depressing drugs, use of, with blood vessel transplants, 234
Pulmonary embolism, prevention of, by anticoagulants, 262–266
by inferior vena caval ligation, 255–261
Pyloroplasty, rationale of, in ulcer-curative surgery, 12
with vagotomy and supra-antral segmental resection for duodenal ulcer, 9–14

RADIATION. See *Irradiation.*
Rectum, polyps of, 35–53. See also *Polyps of colon.*
cancer and, relationship, 45–53
prolapse of, 311–330
classification, 313
definition, 322
one-stage perineal operation for, 313–321
advantages and disadvantages, 319, 320
postoperative care, 319
preparation of patient, 315
techniques, 316
Orr suspension operation for, 322–330
long-term follow-up results, 327–329
principles of, 323
technique of, 324
true, problem in, 314
Reflux esophagitis in hiatal hernia, as cause of symptoms, 58, 65
fundoplication for, 66, 67
Renal failure, acute, 267–295
artificial kidney in, 279–286
indications for, 282
problem of associated tissue damage, 283
of infection, 284
results with, 284
timing of use of, 283
consequences of, 279
diet in, 269–278
electrolyte replacement therapy, 274
fat in, intravenously, 273

Renal failure, acute, fat in, orally and by nasogastric tube, 270
fluid regulation in, 269–278
principles of, 269
glucose in, by continuous drip into saphenous stump or vena cava, 272
insulin and heparin added to, 273
intravenously by simple infusion, 271
orally and by nasogastric tube, 270
testosterone propionate as adjunct to control potassium levels, 271
intestinal perfusion in, 290–293
effects of, 292
indications and contraindications, 291, 292
methods, 290
results with, 292
ion exchange resins in, 274
object of management, 288
peritoneal dialysis in, 287–293
effects of, 290
indications and contraindications, 289
results with, 292
technique, 288
Resection, radical, for carcinoma of head of pancreas, 85–91
segmental, for peptic ulcer, 25–33
indications, 26
rationale of, 26
technique and results, 27–32
supra-antral, with vagotomy and pyloroplasty for duodenal ulcer, 9–14
through gastric corpus, physiologic effects, in duodenal ulcer, 12
Resins, ion exchange, in acute renal failure, 274
Resting level of limb, optimum, in arterial insufficiency of lower extremity, 216
Roentgen diagnosis of small bowel obstruction, 192
Roentgen irradiation of stomach as adjunct to medical treatment of peptic ulcer, methods and results, 5–8
Roentgen treatment of carcinoma of breast, early cases, status of, 183
versus radical mastectomy, 175–183

SCHOEMAKER-Billroth I end-to-end gastroduodenostomy with bilateral vagotomy and antrectomy for duodenal ulcer, rationale, technique, and results, 15–24
Scoops, bile duct, filiform-guided, 113, 114
use of, 112, 113
Sinus, pilonidal, pathogenesis and management, 157–171 See also under *Pilonidal sinus.*
Skin, care of, in arterial insufficiency of lower extremities, 214
Sodium requirements in acute renal failure, 275, 276
Sphincter of Oddi, partial obstruction, instrumental exploration and evaluation in, 114
tonus of, measuring through T-tube, 123
Sphincterotomy, gallbladder function after, 147–153
cholecystographic studies, 150
manometric studies, 147–150
management of normal gallbladder at, 145–156
removal of normal gallbladder at time of, 154–156

Sphincterotomy, with gallbladder left in place, cholecystitis and choledochitis after, 152, 154, 155
cholelithiasis after, 155
Staging breast cancer, clinical method of, 177
Stomach, roentgen irradiation of, as adjunct to medical treatment of peptic ulcer, methods and results, 5–8
ulcer of. See *Gastric ulcer*.
Stones in common duct, detection of, 99–117 See also *Common duct stones*.
Strangulation in small bowel obstruction, recognition of, 199
Stricture of common duct, repair of, 135–143 See also under *Common duct*
Succinylsulfathiazole in preoperative preparation of colon, 298, 301
Suction, gastric. See *Gastric suction*.
Sulfaguanidine in preoperative preparation of colon, 301
Sulfasuxidine. See *Succinylsulfathiazole*.
Sulfathalidine See *Phthalylsulfathiazole*
Survival rates, absolute, as measure of achievement in treating carcinoma of breast, 175
Suspension operation of Orr for prolapse of rectum, technique and evaluation of, 322–330
Sympathectomy, lumbar, for arterial insufficiency of lower extremities, 222, 235, 242, 243–252
arguments against, 250
background of, 243
benefits of, 243–248
preliminary testing for, 244
control of blood cholesterol after, 248
Sympathectomy, lumbar, for arterial insufficiency of lower extremities, drug therapy after, 249
exercise after, 248
prophylactic, 249
Sympathetic block, paravertebral, as test of usefulness of sympathectomy in vascular occlusions, 244
Synthetic vessel prostheses. See *Prostheses, synthetic*.

THROMBO-EMBOLISM, 253–266
anticoagulants in, 262–266
etiology, natural history, and course, 262
inferior vena caval ligation for, 255–261
advantages of, 255
disadvantages of, 256
early and late sequelae, 258
evaluation of factors responsible for leg sequelae, 259
indications for, 257
use of anticoagulants after, 257
of catgut ligatures, 257
venous pressures before and after, 256
prophylactic and therapeutic measures, 263
Thrombo-endarterectomy, for aorto-iliac obstructions, indications and results, 239
for aorto-iliac and femoral obstructions, indications and results, 240
for femoral and popliteal obstructions, indications and results, 241

Thrombo-endarterectomy, for occlusive vascular disease, 234, 238–242
    indications and results, 239–242
    rationale and advantages of, 238, 239
Thrombophlebitis, 253–266
  anticoagulants in, 262–266
  etiology, natural history, and course, 262
  inferior vena caval ligation for, 255–261
  prophylactic and therapeutic measures, 263
Thrombosis, venous, anticoagulants in, 262–266
  etiology, natural history and course, 262
  inferior vena caval ligation in, 255–261
  prophylactic and therapeutic measures, 263
Tibial nerve block as test of usefulness of sympathectomy in vascular occlusions, 245
Tobacco, abstinence from, in arterial insufficiency of lower extremities, 215
Transfusions, blood, in small bowel obstruction, 191
Transthoracic repair of hiatal hernia, principles and technique, 70–73
Trauma, prevention of, in arterial insufficiency of lower extremities, 215
T-tube, removal of, proper time for, after choledochotomy, 116
T-tube drainage of common duct wound, 121–125
    indications for, 132
    precautions prior to insertion of tube, 121
    value of, 122
    versus primary closure, 123
Tube, intestinal decompression, true role of, 197
  use of, in small bowel obstruction, 186, 188, 197–208
  T-. See *T-tube.*

Ulcer, duodenal. See *Duodenal ulcer.*
  gastric. See *Gastric ulcer.*
  peptic. See *Peptic ulcer.*
Ulcerative colitis, carcinoma of colon and, association of, 49

Vagotomy, bilateral, and antrectomy with Schoemaker-Billroth I end-to-end gastroduodenostomy for duodenal ulcer, rationale, technique, and results, 15–24
  rationale of, in ulcer-curative surgery, 12
  with pyloroplasty and supra-antral segmental resection for duodenal ulcer, 9–14
Vascular disease, occlusive. See *Arterial insufficiency.*
Vascular exercises, passive, in arterial insufficiency of lower extremities, 222
Vasodilatation, methods of producing, in arterial insufficiency of lower extremities, 218
Vasodilator drugs, efficacy of, in arterial insufficiency of lower extremities, 219
Vein grafts, autogenous, in arterial insufficiency of lower extremities, 224
Vena cava, inferior, ligation of, for thrombo-embolism, 255–261
    advantages of, 255

Vena cava, inferior, ligation of, for thrombo-embolism,
disadvantages of, 256
early and late sequelae, 258
evaluation of factors responsible for leg sequelae, 259
indications for, 257
use of anticoagulants after, 257
of catgut ligatures, 257
venous pressures before and after, 256
Venous pressures before and after vena caval ligation, 256
Venous thrombosis, anticoagulants in, 262–266
etiology, natural history, and course, 262
inferior vena caval ligation in, 255–261
prophylactic and therapeutic measures, 263
Vivodialysis. See *Hemodialysis.*

WHIPPLE operation for carcinoma of head of pancreas, indications, technique, and results, 85–91
Wound, common duct, management of, 119–134. See also *Common duct wound.*